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THE MINERAL CONSTITUTION OF VARIOUS CERAMIC CLAYS*

By R. E. Grim† and R. H. Bray‡

Abstract

The mineral constitution of samples of ball clay, china clay, Vallendar clay, flint clay, diaspore, shales, brick clays, and fuller's earth has been determined by means of optical, chemical, and X-ray analyses following supercentrifuge fractionation. This technique permits the mineralogical identification of the constituents of the finest fractions, *i.e.*, the so-called colloid fractions of clay materials. Each of the clays investigated, with the exception of diaspore, is essentially composed of one or more of the group of minerals known as the clay minerals, of which kaolinite, beidellite, montmorillonite, and a sericite-like mica are the most important.

On the basis of the foregoing analytical data, the distribution of clay minerals in clays of different types and in different size grade fractions is investigated. The relation between the clay mineral constitution and physical properties is also briefly considered.

Base-exchange capacity determinations are presented and their significance in relation to the mineral composition and physical properties of clays is discussed.

I. Introduction

The object of this paper is to report researches on the mineral constitution of some ceramic clays and to discuss the influence of various mineral constituents on the properties of clays. Attention has been directed especially to the constitution of the finest grade sizes, *i.e.*, the so-called colloid fractions.[1] This research was carried on as part of a general project of the Illinois State Geological Survey designed to investigate the constitution of clays and shales, particularly those found in Illinois, and to study the relation between factors of constitution and properties determining economic utilization.

II. Analytical Procedure

Since the technique used in obtaining the mineral determinations of the clays has been described in detail elsewhere,[2] it will be referred to here very briefly. It consists of (1) removal of easily soluble material and exchangeable bases in order to permit adequate suspension of the colloid fractions; (2) dispersion and sedimentation to separate the particles coarser than one micron in diameter; (3) fractionation of the remaining suspension containing the particles smaller than one micron by means of the supercentrifuge; (4) optical study with the petrographic microscope of the bulk sample and all fractions; (5) X-ray diffraction photography of the colloid fractions; and (6) chemical analyses and base-exchange capacity determinations of the bulk sample and all fractions. In the analysis, the material is separated into four divisions of about the following grade sizes:

	Diameter (microns)
R (residue)	+1
C (coarse colloid fraction)	1–0.1
F (fine colloid fraction)	0.1–0.06
S (superfine colloid fraction)	−0.06

Although the procedure gives some information concerning the size-grade distribution of the constituents of the original sample, its prime purpose is to fractionate the material so that the several mineral constituents are isolated in sufficient purity to permit identification by the optical, chemical, and X-ray data. The residue may be further fractionated for this purpose. The colloid-size grade of many clays is composed of a mixture of minerals. Without fractionation designed to isolate various components, specific mineral identities can not always be determined, and constituents existing in small amounts in the finest colloid-grade sizes may not be detected.

Because of the widespread use of the clays represented by most of the samples, their ceramic properties in general terms are well known and consequently require no special determinations.

* Presented at the Annual Meeting, American Ceramic Society, Columbus, Ohio, April 1, 1936 (White Wares Division). Received June 29, 1936.

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[1] In this paper, for the purpose of description, material existing in particles smaller than one micron in diameter is designated as being of colloidal size.

[2] R. H. Bray, R. E. Grim, and P. F. Kerr, "Application of Clay Mineral Technique to Illinois Clay and Shale," *Bull. Geol. Soc. Amer.*, **46** [12] 1909–26 (1935); *Ceram. Abs.*, **15** [5] 163 (1936).

TABLE I
MATERIALS INVESTIGATED

Sample No.	Kind of material	Source
1	Ball clay	Graves Co., Ky.
2	China clay	Mitchell Co., N. C.
3	Vallendar clay	Ohligs, Germany
4	Pennsylvanian underclay, Cheltenham horizon	Madison Co., Ill.
5	Flint clay	Phelps Co., Mo.
6	Diaspore clay	Phelps Co., Mo.
7	"Indianaite"	Lawrence Co., Ind.
8	Pennsylvanian shale	Menard Co., Ill.
9	Ordovician (Maquoketa) shale	Calhoun Co., Ill.
10	Cretaceous (?) shale	Massac Co., Ill.
11	Cretaceous (?) shale	Alexander Co., Ill.
12	Fuller's earth	Decatur Co., Ga.
13	Fuller's earth	Pulaski Co., Ill.

Ceramic tests were made on some of the samples by the Department of Ceramic Engineering, University of Illinois, under the supervision of C. W. Parmelee.

III. Materials Investigated

The materials investigated (Table I) were selected from a wide range of clays which differ markedly in their physical properties, with a view to obtaining fundamental information for a thorough study of Illinois clays. The Cheltenham underclay, sample 4, is used extensively in making refractories and light-colored face brick. Shale samples 8 and 9 are representative of brick

TABLE II
MINERAL IDENTIFICATIONS

Sample No.	Residue		Colloid fractions: Coarse		Fine		Superfine
1	Kaolinite	VA	Kaolinite	VA	Kaolinite	VA	Kaolinite
	Quartz	A	Sericite-like	VC	Sericite-like	C	Beidellite
	White mica	VC					Sericite-like
							Organic material
2	Kaolinite	VA	Kaolinite		Kaolinite		Beidellite
	White mica	R					Kaolinite
	Quartz	R					Sericite-like
	Orthoclase	R					
3	Quartz	VA	Kaolinite	VA	Kaolinite	VA	Kaolinite
	White mica	C	Sericite-like	VA	Sericite-like	A	Beidellite
	Kaolinite	R					Sericite-like
4	Quartz	VA	Kaolinite	VA	Kaolinite	VA	Kaolinite
	Kaolinite	VC	Quartz	C	Sericite-like	C	Beidellite
	White mica	R	Sericite-like	C			Sericite-like
5	Kaolinite	VA	Kaolinite		Kaolinite		
	Boehmite	VC			Sericite-like		
6	Diasporite	VA	Diaspore	VA		Diaspore	
	(?)	C	Kaolinite	VC		Sericite-like	
			Sericite-like	C		Kaolinite	
7	Halloysite		Halloysite		Halloysite		Halloysite
	Allophane	(?)					
	Kaolinite	(?)					
8	White mica	VA	Sericite-like	VA	Sericite-like	VA	Sericite-like
	Quartz	A	Limonite	R	Limonite	R	Organic material
	Chloritic mica	VR			Beidellite	R	Beidellite
9	Sericite-like	VA	Sericite-like	VA	Sericite-like	A	Sericite-like
	Quartz	VA	Quartz	R	Beidellite	R	Beidellite
	Chloritic mica	VR					Organic material
10	Quartz	A	Kaolinite	VA	Kaolinite	VA	Beidellite
	Kaolinite	A	Sericite-like	C	Beidellite	A	Organic material
	White mica	VC	Quartz	R	Quartz	R	
	Chloritic mica	VR	Beidellite	(?)			
11	Quartz	VA	Sericite-like	VA	Sericite-like	VA	Beidellite
	White mica	A	Quartz	VC	Quartz	R	Organic material
	Chloritic mica	R	Beidellite	(?)	Beidellite	R	Amorphous material
12	(?)		(?)		(?)		(?)
	Quartz	A					
	Glauconite	R					
	White mica	R					
13	Montmorillonite	VA	Montmorillonite *		Montmorillonite *		Montmorillonite *
	Quartz	A					
	Glauconite	R					
	White mica	R					

* X-ray data indicate the presence of a very small amount of kaolinite.

VA = 40% +
A = 40–25%
VC = 25–15%
C = 15–10%
R = 10–5%
VR = –5%

and tile clays widely used in Illinois. Samples 10 and 11 are characteristic of some of the clays in the sediments of the Gulf Coastal Plain showing a considerable mixing of clay minerals. The Georgia (sample 12) and Illinois (sample 13) fuller's earths are illustrative of many bleaching clays. The other samples are representative of well-known ceramic clays.

V. Discussion of Analytical Results

The foregoing mineral analyses show that clays generally are composed of one or more of a comparatively small group of minerals. These minerals, known as the clay minerals (Table IV), are hydrous aluminum silicates and some of them also contain alkalis or alkaline earths. The clay minerals so far investigated have a general micaceous crystalline habit, and, as a consequence, their individual particles are flat and flake-shaped. This characteristic shape is not developed to the same degree in all of them.

In addition to the clay minerals, other constituents, such as quartz, limonite, diasporite, titanium compounds, etc., may also be present in clays (Section VII, pp. 311–12).

The ball clay, which is composed mainly of kaolinite, is noteworthy for its fine size-grade distribution (72% below 1 micron in diameter and no constituents coarser than 10 microns). The china clay is a purer kaolinite clay and has a

TABLE III

MINERAL COMPOSITION SUMMARIZED

Sample No.	
1	Kaolinite (VA); * sericite-like (C): quartz (C); organic material and beidellite (R)
2	Kaolinite (VA); * sericite-like (R); quartz (R); orthoclase (R); beidellite (VR)
3	Kaolinite (VA); * sericite-like (A); quartz (C); beidellite (R)
4	Kaolinite (VA); quartz (A); * sericite-like (R); beidellite (VR)
5	Kaolinite (VA); boehmite (C); sericite-like (VR)
6	Diaspore (VA); (?) (C); kaolinite (VR); sericite-like (VR)
7	Halloysite; kaolinite (?); allophane (?)
8	* Sericite-like (VA); quartz (A); chloritic mica (R); beidellite, limonitic material, and organic material (VR)
9	Sericite-like (VA); quartz (VC); beidellite (R); chloritic mica and organic material (VR)
10	Kaolinite (VA); quartz (A); * sericite-like (VC); beidellite (R); chloritic mica and organic material (VR)
11	Quartz (VA); * sericite-like (VA); beidellite, chloritic mica, organic material, and amorphous material (VR)
12	(?) (VA); quartz (C); white mica and glauconite (VR)
13	Montmorillonite (VA); quartz (VC); white mica, glauconite, and kaolinite (VR)

* Includes "white mica" of the Residue fractions of Table II.

IV. Mineral Constitution of Material Investigated

The identifications (Table II) of the mineral constituents of the colloid fractions are based on a comparative study[2] of the analytical data in the Appendix(pp. 314–15) with similar data for specific clay minerals. The coarser constituents have been studied with the petrographic microscope. The compositions are summarized in Table III, in which the relative abundance of the important constituents is estimated for each clay without reference to the particle size in which they occur.

TABLE IV

COMMON CLAY MINERALS

Name	Chemical composition	Remarks
Kaolinite	$Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$	Anauxite and kaolinite form an isomorphous series
Anauxite	$Al_2O_3 \cdot 3SiO_2 \cdot 2H_2O$	
Halloysite	$Al_2O_3 \cdot 2SiO_2 \cdot xH_2O$	
Beidellite	$*Al_2O_3 \cdot 3SiO_2 \cdot xH_2O$	Beidellite and nontronite form an isomorphous series
Nontronite	$*Fe_2O_3 \cdot 3SiO_2 \cdot xH_2O$	
Montmorillonite	$*Al_2O_3 \cdot 4SiO_2 \cdot H_2O$	Montmorillonite, beidellite, and nontronite probably contain essential alkalis or alkaline earths
Sericite-like mineral	$*2K_2O \cdot 3MO \cdot 8R_2O_3 \cdot 24SiO_2 \cdot 12H_2O$	

* These formulas are to be regarded as tentative pending further researches.

coarser size-grade distribution than the ball clay.

The German Vallendar clay, like the ball clay in being very fine grained, is essentially a mixture of the sericite-like mineral and kaolinite. The analytical data for the shales (samples 8 and 9) show that the sericite-like mineral commonly contains iron isomorphously replacing aluminum. It also contains magnesia. In the Vallendar clay, this mineral contains unusually small amounts of these components, which is an important reason for certain of the fired properties of this clay.

The Cheltenham clay is illustrative of a kaolinitic underclay of Pennsylvanian age. Other underclays beneath coals of Pennsylvanian age have been analyzed, and some of them are composed of a mixture of kaolinite and the sericite-like mineral. A few are known which are composed largely of beidellite.

The flint clay contains very little material smaller than the coarse colloid fraction. No halloysite[3] could be specifically identified in the material investigated. Optical and X-ray data indicate the presence of a mineral mixed with kaolinite in the residue which, on the basis of its optical properties, has been identified as boehmite.[4]

The diaspore clay has a small amount of material of coarse colloid size and only a trace of material finer than this size. In addition to diasporite, the sample studied contains a mineral which can not be positively identified. It is probably a form of Al_2O_3 which may be unhydrated. Optical data suggest that a small amount of a mineral resembling boehmite is also present. According to Allen,[3] the titanium in the diaspore clays from this area (Missouri) occurs in leucoxene.

The "indianaite" residue and coarse colloid fractions are made up of aggregates of particles of halloysite less than 0.1 micron in diameter in random orientation. In the fine and superfine colloid fractions, individual particles of halloysite have been obtained from the original aggregates and then formed on drying into aggregates of uniform crystallographic orientation. The optical data of the mineral in these fractions, which can be determined accurately, indicate that it is anisotropic. Mehmel[5] obtained metahalloysite by heating halloysite to 105°C. Although the material in the process of analysis was not subjected to 105°C, the optical and X-ray data of the fractionated samples are those of metahalloysite (as given by Mehmel) rather than halloysite.

The "indianaite" selected for analysis was probably unusually rich in halloysite, since investigations[6] indicate that some specimens may contain kaolinite and alunite.

Shale samples 8 and 9 are illustrative of the composition of many shales which have been studied. The sericite-like mineral, which is their chief constituent, is somewhat similar to muscovite but contains more silica, more water, and less potash. It also usually contains magnesia. It possesses certain similarities to beidellite so that when it occurs in the superfine-colloid fraction it may be confused with this mineral. Much of the so-called "hydromica" is probably of this character. The tentative formula, $2K_2O \cdot 3MO \cdot 8R_2O_3 \cdot 24SiO_2 \cdot 12H_2O$, has been assigned to the mineral pending its further study and specific naming.

The sericite-like mineral, shown by X-ray analyses and optical determinations,[7] is similar to the "glimmerton" of Endell,[8] Hofmann, and their co-workers. The widespread occurrence of this sericite-like mineral to the almost complete exclusion of all others in shaly sediments indicates a close relationship between the laminated structure of shales and the presence of this mineral. In such sediments, the individual flake-shaped particles are usually uniformly oriented with their long axes parallel to the lamination. Different shales vary widely in the abundance of quartz, calcite, and other minerals which dilute the sericite-like mineral.

[3] V. T. Allen, "Mineral Composition and Origin of the Missouri Flint and Diaspore Clays," *Mo. Geol. Surv., 58th Biennial Rept.*, Appendix IV, 24 pp. (1935).

[4] Boehmite is a monohydrate structurally distinct from diasporite. See (*a*) J. Boehm, "Aluminum and Ferric Hydroxide," *Z. anorg. allgem. Chem.*, **149**, 203–16 (1925); (*b*) J. de Lapparent, "The Hydrated Alumina of Bauxite," *Compt. Rend.*, **184**, 1661–62 (1927); *Ceram. Abs.*, **7** [4] 253 (1928).

[5] M. Mehmel, "Structure of Halloysite and Metahalloysite," *Z. Krist*, **90**, 35–43 (1935); *Ceram. Abs.*, **14** [11] 291 (1935).

[6] (*a*) H. Ries, "High-Grade Clays of the Eastern United States," *U. S. Geol. Surv. Bull.*, No. 708, p. 156 (1922).
(*b*) C. S. Ross and P. F. Kerr, "Halloysite and Allophane," *U. S. Geol. Surv. Prof. Paper*, No. 185-G (1934).

[7] This similarity was determined following an interchange of material by Hofmann and Grim. X-ray analyses were made on the exchanged material by Hofmann; optical analyses by Grim.

[8] K. Endell, U. Hofmann, and E. Maegdefrau, "The Nature of the Clay Constituents in Raw Materials of the German Cement Industry," *Zement*, **24**, 625–32 (1935).

Samples 10 and 11 are characteristic of many sedimentary clays and shales of the Coastal Plains. They illustrate considerable mixing of clay minerals and sample 11 illustrates further the shaly structure which occurs in a sediment when the sericite-like mineral is the chief constituent.

Additional study is necessary to identify specifically the dominant constituent in sample 12. Although its optical characters are those of montmorillonite, it differs from this mineral in its X-ray diffraction pattern. Its silica and magnesia content are high, but Noll[9] has recently shown that the composition of montmorillonite, particularly in regard to magnesia, may vary. The name, "attapulgite,"[10] has been suggested for this mineral, but it is not well established. Likewise, there is a possibility that the material is a mixture of montmorillonite and a hydrated magnesium-silicate mineral similar to sepiolite.

The silica content of the superfine fraction of sample 13 determined as montmorillonite is notably higher than the usual value for this mineral.[11] In the absence of evidence for the presence of any other crystalline mineral in this fraction, the silica content signifies either the presence of amorphous silica or that the ratio of silica to R_2O_3 in montmorillonite may vary within wide limits.

VI. Distribution and Occurrence of Clay Minerals

The following statements are based on the preceding mineral analyses plus a large number of analyses of other clays and shales which are not presented here. These analyses warrant the conclusion that kaolinite, beidellite, montmorillonite, the sericite-like mineral, and halloysite are the most important clay minerals.

(1) Kaolinite

Kaolinite most commonly is in particles about 1 micron in diameter. Particles of this size and relatively unimportant larger ones usually are not reduced in size by disaggregation processes to less than 0.1 micron in diameter. It occurs as an essential constituent of kaolins, ball clays, refractory underclays, certain flint clays, and some sedimentary clays. Since many clays and probably most shales contain no kaolinite, the presence of the mineral is not to be assumed in all argillaceous sediments.

(2) Beidellite

Beidellite occurs in particles of the finest colloid sizes (−0.1 micron), or larger ones which can be disaggregated to this size. It occurs widely in the finest colloid fractions of clays which are dominantly composed of other clay minerals. Many recent soils and Pleistocene argillaceous deposits, particularly gumbotils, consist primarily of this mineral. A few bentonites also contain it.

(3) Montmorillonite

Montmorillonite, like beidellite, is found in particles of the finest colloid sizes or in larger ones which can be broken down easily to this size. It is the essential constituent of most bentonites and of some sedimentary clays, *e.g.*, the Porters Creek clay of Eocene age of southern Illinois, which is extensively used as a fuller's earth.

(4) Halloysite

Halloysite occurs in minor amounts in the finest colloid fractions of some kaolinitic clays.[12] Its presence in such clays is difficult to establish because of similarities with extremely fine kaolinite. It is found also in some lateritic soils and flint clays. The mineral is very abundant in much "indianaite," where particles of very fine colloid sizes exist in random aggregation, producing the effect of isotropism in the clay as a whole.

(5) Sericite-Like Mineral

The sericite-like mineral is usually present in particles slightly coarser than 1 micron, in some instances with a diameter of several millimeters. It occurs occasionally in particles of the finest colloid sizes, whereas the larger particles can not usually be disaggregated to this size.

It is the prime constituent of most shales and a minor constituent of many clays. The K_2O reported in a clay or shale by chemical analysis is present commonly in this mineral.

VII. Distribution and Occurrence of Quartz, Limonite, Diasporite, Organic Material, and Amorphous Material in Clays

(1) Quartz

Quartz may occur in varying amounts in all

[9] W. Noll, "Synthesis of Montmorillonite," *Chem. Erde*, **10**, 129–54 (1936).

[10] J. de Lapparent, "Important Constituent of Fuller's Earth," *Compt. Rend.*, **201** [10] 481–83 (1935); *Ceram. Abs.*, **15** [1] 38 (1936).

[11] U. Hofmann, K. Endell, and D. Wilm, "Crystal Structure and Swelling of Montmorillonite," *Z. Krist.*, **86** [5–6] 340–48 (1933); *Ceram. Abs.*, **13** [4] 100 (1934).

[12] See footnote reference 6(*b*), p. 310.

clays with the possible exception of some highly aluminous or lateritic clays. It has been found in particles of all sizes from several millimeters to about 0.06 micron in diameter.[13] In material of smaller size no quartz is detected.

(2) Limonite

Limonite is a constituent of minor abundance in most clays and of major abundance in a few (lateritic) clays. It usually is most prevalent in the fine colloid fraction.

(3) Diasporite

Diasporite and other hydrated alumina compounds are generally absent in all clays except the diaspores and bauxites.

(4) Organic Material

Organic material, which is not fragmentary lignitic material, tends to be concentrated in the superfine colloid fraction. Although a clay may be black or brown because of organic material, the amount of such material is usually small (*e.g.*, 2% in sample 1).

(5) Amorphous Material

Amorphous material is generally absent from clays and shales. There is a suggestion of a small amount of inorganic material which is not definitely crystalline in the superfine fraction of a very few clays and shales (sample 11).

VIII. Base-Exchange

The importance of base-exchange for ceramic clays has recently been emphasized by Endell, Hofmann, and Wilm.[14] It has been shown that certain properties of clays are related to their base-exchange capacity and to the amount and nature of the exchangeable ions which they contain. The base-exchange capacities given in Table V were obtained by leaching the samples with ammonium acetate, followed by washing with neutral absolute alcohol. The replaceable ammonia was determined by distillation.

The data (Table V) show that base-exchange capacity is different for different clays and that within each clay the capacity apparently increases with decreasing particle size. The base-exchange capacity of the whole clay does not indicate how this property is distributed within the size fractions. In general, extremely small particle size and higher base-exchange capacity are associated with the beidellite or montmorillonite clay minerals, and much lower capacities and coarser particle size are associated with kaolinite and the sericite-like mineral. Sufficient researches have not been completed to ascribe specific exchange capacities to specific clay minerals or to say positively that certain clay minerals have no exchange capacity.

TABLE V

BASE-EXCHANGE CAPACITY IN MILLIEQUIVALENTS PER 100 GRAMS

Sample No.	Whole clay	Residue	Coarse	Fine	Superfine
1	13.0	10.3	15.5	31.0	31.0
2	4.4	5.1	13.1		
3	12.6	4.0	15.0	30.0	
4	17.5	6.8	23.5	33.7	56.9
5	5.0	3.6	7.4		
6	2.8	1.0	15.0		
7	12.6	10.0	15.5	17.0	
8	11.2	10.3	18.5	21.6	33.0
9	11.4	5.7	13.0	20.0	27.5
10	14.6	6.8	30.5		44.0
11	9.7	6.8	20.0	30.0	41.7
12	27.0	21.0	19.4	21.0	40.0
13	45.0	43.0	57.0	76.6	78.0

Computation based on analytical data for a large number of clays, soils, and shales affords some evidence that base-exchange is not possessed by all clay minerals. Thus, in the case of shales composed of mixtures of the sericite-like mineral and beidellite, the suggestion is that the seat of the exchange capacity is in the beidellite, the sericite-like mineral not possessing this property. On the basis of this concept, the small exchange capacities of the coarser fractions of the shale, sample 9, which are composed essentially of the sericite-like mineral, are viewed as the result of very small quantities of admixed beidellite-type material. Optical and X-ray data do not entirely agree with this interpretation, but there is some question whether the small amounts of admixed material required could be detected by such data.

The alternative concept is that such clay minerals as kaolinite and the sericite-like mineral themselves possess exchange capacity. If this view is correct, the exchange capacity of these minerals is small—only a fraction of that possessed by montmorillonite or beidellite. Thus far only these latter two clay minerals are known definitely[15] to possess relatively high exchange ca-

[13] See footnote reference 2, p. 307.

[14] K. Endell, U. Hofmann, and D. Wilm, "Nature of Ceramic Clays," *Ber. deut. keram. Ges.*, **14** [10] 407–38 (1933); *Ceram. Abs.*, **13** [4] 101 (1934).

[15] Data concerning the base-exchange capacity of halloysite are conflicting. See Third International Congress of Soil Sci., Vol. III, pp. 84–99 (1936).

pacities, and it is probable that when capacities of over 35 milliequivalents are present in a clay it contains appreciable amounts of these minerals.

Quantitative determinations of the replaceable bases have not yet been made, but qualitative tests show that they are mainly calcium, magnesium, and hydrogen in the clays studied. Clays highly saturated with the sodium ion are found occasionally. The importance of this field of research should be emphasized following the studies of Endell[14] and his co-workers.

IX. Relation of Clay Minerals to Ceramic Properties

The effect of various clay mineral constituents on ceramic properties is not easy to evaluate because of the difficulty in untangling the influence of particle size within the colloid range from the influence of specific minerals. Vastly more research is needed before conclusions can be given in specific terms. The following statements are based on much mineralogic and ceramic data which can not be included in the present paper.

Beidellite exerts a very important influence on unfired properties. Thus, drying shrinkage and bond strength increase as the relative amount of this constituent increases. It may be suggested that a contributing cause for the variations in the green properties of china clays is the generally undetected varying amount of beidellite which they contain. Since this clay mineral has a high base-exchange capacity, the influence of base-exchange phenomena on physical properties will be felt to a high degree by clays composed largely of beidellite. As alkalis are commonly present in this mineral, clays containing appreciable quantities of it are not apt to be refractory. Furthermore, in many instances the aluminum in the mineral is isomorphously replaced by iron, and, as a consequence, there is a tendency toward red-firing colors.

Montmorillonite exerts an influence similar to beidellite but with greater intensity. When it is recognized that montmorillonite is the constituent of most bentonites, the well-known fact that adding bentonite[16] to kaolins tends to increase their plasticity, etc., is further evidence for the conclusion that montmorillonite exerts an important control on green properties.

Montmorillonite is the essential constituent of most clays with high ability to decolorize oils,[17] *e.g.*, fuller's earths.

Factors of texture and relative abundance being equal, kaolinite appears to yield lower values for unfired properties than does beidellite. Largely because kaolinite carries no constitutional alkalis, has low or no base-exchange capacity and therefore few if any adsorbed basic ions, and its aluminum is not isomorphously replaced by iron, it is more refractory than the other clay minerals. The absence of iron, likewise, favors light-firing colors.

The high values for the green properties of ball clay, which is a kaolinitic clay, result from the combination of the degree of fineness, the relative abundance of organic material in the superfine colloid fraction, and the presence of beidellite.

With equivalence in texture and relative abundance, the sericite-like mineral tends to yield lower values for unfired properties than kaolinite. As a consequence of the constitutional potash, the mineral is not refractory. Analytical data (Appendix) strongly indicate that at least part of the aluminum in the mineral may be replaced isomorphously by iron. Materials containing the mineral in considerable amounts, therefore, usually exhibit red-firing colors. The tendency of potash micas to inhibit the formation of cristobalite on firing has been noted by several investigators.[18]

Explanatory Data for Appendix (pp. 314–15)

Chemical analyses of samples 1 and 3 to 11 were made under the supervision of O. W. Rees, Associate Chemist, Illinois State Geological Survey, and of samples 2, 12, and 13 were made under the supervision of R. H. Bray.

X-ray diffraction analyses of samples 1, 2, 3, 4, 5, 6, 7, 12, and 13 were made by W. F. Bradley, Assistant Chemist, Illinois State Geological Survey, and of samples 8 to 11 by P. F. Kerr, Columbia University.

* The loss on ignition values for samples 12 and 13 are based on air-dried material; for samples 1 to 11 are based on material dried to 110°C.

R = residue
C = coarse colloid fraction
F = fine colloid fraction
S = superfine colloid fraction
S† = strong line in diffraction pattern
W = weak lines in diffraction pattern
VW = very weak lines in diffraction pattern

[16] P. E. Cox, "Study of Plasticity by Practical Potters Methods," *Jour. Amer. Ceram. Soc.*, 7 [3] 151–53 (1924).

[17] R. E. Grim, "Petrography of the Fuller's Earth Deposit, Olmsted, Illinois, etc.," *Econ. Geol.*, **28** [4] 345–63 (1933); *Ceram. Abs.*, **13** [2] 49 (1934).

[18] (*a*) R. A. Heindl, W. L. Pendergast, and L. E. Mong, "Kaolins: Effect of Firing Temperatures on Some of Their Physical Properties," *Bur. Stand. Jour. Research*, **8** [2] 199–215 (1932); *Ceram. Abs.*, **11** [6] 387 (1932).
(*b*) K. Endell, U. Hofmann, and D. Wilm, "Clays Containing Quartz and Mica," *Sprechsaal*, **67** [20] 293–95; [21] 309–11; [22] 325–28 (1934); *Ceram. Abs.*, **14** [6] 153 (1935).

Appendix—Analytical Data (See Explanatory Data on p. 313)

Sample No.	1				2				3			
	R	C	F	S	R	C	F	S	R	C	F	S
SiO_2	65.70	47.19	45.05	42.65		44.79			85.40	46.97	47.10	43.78
Al_2O_3	20.95	35.96	36.52	32.44		40.31			6.99	35.51	36.93	34.16
Fe_2O_3	0.40	0.85	1.15	1.64		0.36			0.56	0.64	0.69	1.40
FeO	0.20								0.06	0.12	0.10	
MgO	0.37	0.59	0.64	0.67		0.01			0.42	0.80	0.85	1.11
CaO	0.31	0.28	0.24	1.21		0.04			0.03	0.03	0.03	0.05
Na_2O	0.13	0.02	0.14	0.15					0.20	0.43	0.49	0.85
K_2O	1.27	0.92	0.87	1.37		0.07			1.26	3.46	2.91	3.64
TiO_2	1.69	1.39	0.91	2.00					3.25	2.17	0.71	0.46
Ignition loss*	9.18	12.48	14.13	18.10		16.03			2.00	9.92	10.82	14.42
Total	100.20	99.68	99.65	100.23		101.61			100.17	100.05	100.63	99.87
H_2O+	7.31	12.44	13.68	15.07		14.35			2.00	10.00	10.72	
H_2O-	0.62	1.84	2.91	4.68		1.50			0.10	1.14	1.68	3.10
SiO_2/R_2O_3	5.26	2.20	2.06	2.14		1.87			19.45	2.22	2.14	2.12
Optical data		Homogeneous aggregates $\gamma - \gamma = 1.565$ $\gamma - \alpha = 0.010$	Aggregates $\gamma = 1.570$ $\gamma - \alpha = 0.013$ 2V = small	Aggregates $\gamma = 1.575$ $\gamma - \alpha = 0.020$ 2V = small		Aggregates $\beta = 1.555$ Low birefringence	Homogeneous aggregates $\gamma = 1.565$ $\gamma - \alpha = 0.025$ 2V = medium			Aggregates $\gamma = 1.570$ $\gamma - \gamma = 0.015$	Aggregates $\gamma = 1.570$ $\gamma - \alpha = 0.015$	Aggregates $\gamma = 1.570$ $\gamma - \alpha = 0.020$
X-ray data		Kaolinite (S)† Sericite-like (VW)	Kaolinite (S) Sericite-like (VW)	Kaolinite Sericite-like		Kaolinite	Homogeneous aggregates Kaolinite $\gamma = 1.561$ $\gamma - \alpha = 0.005$	Kaolinite Sericite-like		Kaolinite (S) Sericite-like (S)	Kaolinite (S) Sericite-like (S)	Kaolinite Sericite-like
Total clay (%)	28.0	56.5	11.4	4.2	80.0	19.8	Trace	Trace	15	50	20	15

Sample No.	8				9				10			
	R	C	F	S	R	C	F	S	R	C	F	S
SiO_2	61.52	44.79	44.01	41.18	69.50	49.96	50.10	51.27		48.64	47.78	48.27
Al_2O_3	18.92	27.96	26.81	20.01	13.30	23.77	25.12	21.48		33.77	33.59	27.10
Fe_2O_3	4.86	8.58	11.99	6.88	3.49	6.37	5.12	5.11		2.32	3.15	3.93
FeO	1.83	1.79			1.55	2.06	1.52	1.50				
MgO	1.93	2.58	2.43	1.37	1.60	3.59	3.93	3.84		0.38	0.53	0.80
CaO	0.21	0.13	0.11	0.69	1.48	0.45	0.45	1.04		0.39	0.63	1.99
Na_2O	0.96	0.24	0.07	1.69	0.07	0.35	0.05	0.41		0.25	0.28	0.56
K_2O	3.23	4.63	4.78	3.35	4.36	6.44	6.93	6.41		2.48	2.16	2.30
TiO_2	1.41	0.68	0.64	0.39	1.48	1.04	0.50	0.37		0.96	0.68	0.46
Ignition loss*	5.36	8.64	9.19	24.58	3.25	6.77	6.82	8.81		10.88	11.38	14.55
Total	100.23	100.00	100.03	100.14	100.08	100.80	100.44	100.24		100.07	100.18	99.96
H_2O+	5.63	7.67	8.08	8.62	2.47	6.35	7.18	6.19		10.86	11.31	11.84
H_2O-	0.47	1.23	2.33	6.66	0.19	0.87	1.90	2.77		0.82	2.52	3.47
SiO_2/R_2O_3		2.27	2.17	2.87		3.05	3.00	3.51		2.35	2.28	2.43
Optical data		Aggregates $\gamma = 1.595$ $\gamma - \alpha = 0.030$ Pigmentary limonite	Aggregates $\beta = 1.610$ $\gamma - \alpha = 0.035$ Pigmentary limonite	Aggregates mainly $\gamma = 1.595$; Very few aggregates; Birefringence low $\gamma - \alpha = 0.025$ $\beta = 1.540$		Aggregates $\gamma = 1.597$ $\gamma - \alpha = 0.030$	Aggregates $\gamma = 1.597$ $\gamma - \alpha = 0.032$	Homogeneous aggregates $\gamma - \gamma = 1.594$ $\gamma - \alpha = 0.030$; (–) 2V = small		Aggregates whose indices range from 1.575 to 1.555; for most of them $\gamma = 1.570$ $\gamma - \alpha = 0.009$	Aggregates $\gamma = 1.575$ $\gamma - \alpha = 0.019$	Aggregates mainly $\gamma = 1.569$ Very few appear isotropic; $\gamma - \alpha = 0.034$ $n = 1.530$
X-ray data		Impure sericite-like				Sericite-like (S) Quartz (VW)	Sericite-like	Sericite-like		Kaolinite (S) Beidellite (W) Quartz (W) Sericite (W) Beidellite (?)	Kaolinite (S) Beidellite (W) Quartz (VW)	Beidellite
Total clay (%)	87	9.5	1.5	1.6	44	34	12	10	69.3	22.0	6.7	2.0

Appendix—Analytical Data (*concluded*)

Sample No.	4				5			6			7			
	R	C	F	S	R	C	F	R	C	FS	R	C	F	S
SiO_2		48.10	47.08	49.34	37.81	43.79		0.85	15.74	38.78	45.05	44.58	44.63	
Al_2O_3		37.24	36.35	33.85	44.08	40.67		80.08	63.97	38.41	39.73	40.37	39.80	
Fe_2O_3		1.47	1.85	1.96	0.61	0.62		0.65	1.34	4.31	0.47	0.20	0.52	
FeO					0.08	0.08		0.02	0.26	n.d.	0.05	0.09	n.d.	
MgO		0.84	1.12	0.98	0.23	0.21		0.33	0.74	1.04	0.11	0.18	0.20	
CaO		0.25	0.23	0.16	0.06	0.05		0.04	0.05	0.00	0.05	0.24	0.07	
Na_2O		0.06	0.07	0.09	0.13	0.14		nil	0.46	n.d.	nil	0.00	0.04	
K_2O		0.76	0.83	1.30	0.34	0.42		nil	1.42	n.d.	0.20	0.00	0.16	
TiO_2				0.57	3.66	1.08		3.96	3.48	2.71	0.00	0.00	0.00	
Ignition loss*		12.02	12.30	12.10	13.65	13.64		14.76	12.34	12.31	15.08	15.08	15.12	
Total		100.74	99.83	100.35	100.65	100.70		100.69	99.80	97.56	100.74	100.74	100.63	
H_2O+		12.21	12.09	11.21	13.68	13.70		15.00	12.09	n.d.	15.25	15.35	n.d.	
H_2O-		2.46	2.77	7.09	0.23	0.61		0.05	0.53	3.43	7.03	4.53	4.10	
SiO_2/R_2O_3		2.14	2.14	2.38	1.45	1.81				1.60	1.91	1.87	1.89	
Optical data		Aggregates $\gamma - \alpha = 0.010$ $\gamma - \gamma = 1.570$	Aggregates $\gamma - \alpha = 0.010$ $\gamma - \gamma = 1.570$	Aggregates $\gamma - \alpha = 0.020$ $\gamma - \gamma = 1.570$	Aggregates $\beta = 1.568$ Faintly anisotropic		Aggregates $\gamma - \alpha = 0.010$ $\gamma - \gamma = 1.572$		Aggregates $\beta = 1.70$	Aggregates $\gamma - \alpha = 0.025$ $\gamma - \gamma = 1.603$ 2V = small	Homogeneous aggregates $\gamma - \alpha = 0.003$ $\gamma - \gamma = 1.546$	Homogeneous aggregates $\gamma - \alpha = 0.005$; (−) $\gamma - \gamma = 1.550$ 2V = medium	Homogeneous aggregates $\gamma - \alpha = 0.005$ $\gamma - \gamma = 1.550$	
X-ray data		Kaolinite (S) Quartz (W)	Kaolinite (S) Sericite-like (VW)	Kaolinite Sericite-like	..... (?)	Kaolinite (S)	Kaolinite Sericite-like	..... (?)	Diasporite (S)	Diasporite (S) Kaolinite (W) Sericite-like (VW)	Sericite-like Kaolinite	Halloysite	Halloysite	Halloysite	
Total clay (%)	50	36	8	7	50.4	48.0	1.6	88.2	11.2	0.6	55.6	39.8	4.6	Trac

Sample No.	11				12				13			
	R	C	F	S	R	C	F	S	R	C	F	S
SiO_2		57.36	52.32	49.29	61.94	60.53	55.03	54.86	66.12	60.78	55.12	60.78
Al_2O_3		23.67	25.85	16.29	9.65	12.22	10.24	11.59	14.41	16.08	18.10	13.18
Fe_2O_3		3.55	4.04	2.74	3.49	3.68	3.53	4.43	6.73	8.83	8.70	5.86
FeO												
MgO		1.81	2.69	2.52	7.84	6.81	10.49	8.51	1.27	1.54	2.39	1.92
CaO		0.54	0.60	1.77		0.07		0.18	0.06	0.21	0.27	0.50
Na_2O		0.43	0.33	0.98								
K_2O		5.43	6.56	4.01	1.12	1.98	0.47	0.56	1.65	1.40	1.21	0.65
TiO_2		0.84	0.37	0.22								
Ignition loss*		6.68	7.88	22.37	15.91	14.46	20.25	19.63	9.58	11.48	14.40	16.23
Total		100.31	100.55	100.19	99.95	99.75	100.01	99.76	99.82	100.32	100.28	99.12
H_2O+		6.36	7.88	13.17	8.04	7.27	10.13	9.52	5.09	6.10	6.82	5.95
H_2O-		0.68	1.13	5.95	7.69	6.52	9.73	9.21	4.26	4.87	6.42	8.07
SiO_2/R_2O_3		3.73	3.12	4.61	8.85	7.05	7.48	6.46	6.00	4.75	3.96	6.10
Optical data		Aggregates whose indices range from 1.502 to 1.555; for most of them $\gamma - \alpha = 0.032$ $\gamma - \gamma = 1.502$		Same as 11 C		Aggregates $\gamma - \alpha = 0.032$ $\gamma - \gamma = 1.540$	Homogeneous aggregates $\gamma - \alpha = 0.032$; (−) $\gamma - \gamma = 1.540$ 2V = small	Homogeneous aggregates $\gamma - \alpha = 0.032$; (−) $\gamma - \gamma = 1.540$ 2V = small		Aggregates $\beta = 1.540$ $\gamma - \alpha = 0.030$	Homogeneous aggregates $\gamma - \alpha = 0.030$ $\gamma - \gamma = 1.550$	Homogeneous aggregates $\gamma - \alpha = 0.030$; (−) $\gamma - \gamma = 1.550$ 2V = small
X-ray data		Sericite-like (S) Quartz (W) Beidellite (?)		Sericite-like (S) Quartz (W) Beidellite (?)		..... (?)	..... (?)	..... (?)		Montmorillonite (S) Kaolinite (W)	Montmorillonite (S) Kaolinite (W)	Montmorillonite Kaolinite
Total clay (%)	71.6	18.5	8.3	1.6	32.4	9	25.2	33.4	61.2	22.4	4.8	11.8

Aggregates whose indices range from Beidellite 1.575 to 1.520; a few are definitely anisotropic; $\beta = 1.565$; $\gamma - \alpha = 0.025$

NOTE ON A NEW DRY-PRESS DE-AIRING DEVICE*

By C. E. Curtis

Abstract

Three general methods for de-airing a dry press are (1) double-pressing, (2) use of an easily condensable gas, and (3) direct de-airing. In an investigation of the latter it was found best to evacuate the mold box through holes drilled in the die pads. To keep the holes free of clay, a device called a "cleaning grid" was developed. A description of the construction and operation of an installation of this device is given.

I. Introduction

The benefits to be derived from de-airing a dry-press brick have been demonstrated by Dodd,[1] Birch,[2] Rueckel,[3] Everhart,[4] and others. They have shown that if sufficient air is removed from the batch, the ware may be subjected to as much pressure as the machinery will stand and will not pressure-crack.

Three methods for removing the air from the dry-press batch are as follows: (1) double-pressing, (2) use of an easily condensable gas, and (3) direct de-airing. Of these, double-pressing involves heavy and expensive presses and slower operation; the gas method, unless adequately protected, involves a fire hazard; direct de-airing, therefore, seems to be the most promising.

Direct de-airing consists in removing the air from the unpressed batch in the mold box of the press. The term might also be made to include an operation which is sometimes feasible, namely, that of allowing the air to escape under its own pressure. The chief difficulty in either case is that of keeping the passages open for the escape of the air.

The importance of this problem is seen if the operation of the press is considered. It is apparent that the removal of the air must take place during the comparatively short interval between the time when the upper die enters the mold box and when the batch has become too compacted to permit further rapid escape of the air. In the case of a press with a cycle of 8 seconds, this interval would be less than 4 seconds.

Whether the air is removed through openings in the sides of the mold box or in the die pads, it certainly will not have time to travel far, impeded as it is by the loose clay particles. This was demonstrated by experiments in this laboratory in which three brick were side-pressed at 5000 pounds per square inch. One of these was not de-aired and it was pressure-cracked midway between the sides and at right angles to the direction of pressure application (Fig. 1, *B*). A second brick was de-aired from the bottom only. In this case the pressure cracks were close to the undeaired side, showing that the air from the upper side of the batch had not had time to escape (Fig. 1, *C*). A third brick which was de-aired from both top and bottom had no pressure cracks (Fig. 1, *A*).

Inasmuch as these experiments were conducted on a slow-acting hydraulic press, it is apparent that the more rapid commercial presses will require plenty of outlets well distributed around the charge. It is apparent also that unless the openings are kept open continuously there is no assurance that the ware is being well de-aired or deaired at all. A few openings or even many openings not well distributed might not be much better than no openings.

A suggested method for keeping the air outlets clear consists in applying air pressure to them between pressing cycles. That not many openings can be kept clear in this manner is evident because as soon as a few openings are blown clear the air pressure across the surface will drop and no more openings will be affected. This has been demonstrated.

II. Die Plates Permit Air Escape

In response then to the need of a simple and positive method for keeping the air outlets open, the device described here was developed. The

* Presented at the Annual Meeting, American Ceramic Society, Columbus, Ohio, April 1, 1936 (Refractories Division). Received May 20, 1936.

[1] C. M. Dodd, "Investigations of the Dry-Press Process," *Natl. Paving Brick Mfrs. Assn. Bull.*, Nos. 109 *et seq.*

[2] R. E. Birch, "Researches in Dry-Press Refractories: I, Relation of Forming Pressure to Physical Properties," *O. S. U. Eng. Expt. Sta. Bull.*, No. 56, 50 pp. (1930).

[3] W. C. Rueckel, "Researches in Dry-Press Refractories: II, Prevention of Pressure Cracking," *ibid.*, No. 82, 36 pp. (1934).

[4] J. O. Everhart, "The Dry-Press Method of Making Paving Brick," *O. S. U. Eng. Expt. Sta. Circ.*, No. 31, 20 pp. (1934).

FIG. 1.—De-aired, unde-aired, and partially de-aired fire brick. (*A*) Completely de-aired; air withdrawn from top and bottom; note even structure. (*B*) Unde-aired; pressure cracks through middle of brick perpendicular to direction of pressure application. (*C*) Air withdrawn only from bottom of brick; pressure crack near top of brick indicates imperfect de-airing.

apparatus can be installed either in the walls of the mold box or in the die pads. The following description will apply to the die pad adaptation.

Three plates, designated *A*, *B*, and *C*, taken together, replace the ordinary die pad (see Fig. 2). *C* is the top plate of the three and the one against the upper side of which the ware is pressed. It contains the air outlets, the size, shape, and distribution of which can be varied to suit conditions. The lower side of *C* is ribbed and these ribs match similar ones on the lower plate, *A*, and thus support plate *C* against the pressure of the clay.

Plate *A* is mainly a supporting plate for *C*. It has a central opening, however, through which the escaping air is conducted away. These two plates taken together constitute essentially the set-up which has been plant-proved. The general idea which this set-up embodies was patented in 1921 by Dimitri and Delauney.[5]

Plate *B* is the essentially new feature that was developed to assure even and continuous de-airing of the dry press by the direct method. It is so constructed that it fits into the grooves in *A* and *C* with room to move straight up and down for a fraction of an inch. It is studded with projections which match the openings in *C*. It is actuated by a vertical lift rod through the plunger of the press and working through the central opening in *A*. The escaping air will pass out around this lift rod or through an opening in the rod itself.

III. Operation of the Device

Suppose the device be installed in the lower plunger of the dry press. The plunger is at the bottom of its stroke where it is receiving the charge of clay. At that point, plate *B* will be in its higher position where the studs on its upper surface will close the openings in *C*, thus preventing any clay from dropping through. As soon as the clay charge is in place, the upper plunger moves downward and closes the mold box; at about that moment *B* will be moved downward a short distance. Immediately every opening in *C* is clear for the escape of the air. This air flows around *B* and along the grooves to the central outlet through which it escapes.

The other stage in the operation of the device occurs when the clay begins to become compacted. All of the air that can be removed from the batch is out. Thereupon *B* is pushed upward again, forcing the projections back into the openings in *C*. In this way the outlets are effectively cleared for the next de-airing operation. The outlets are thus kept closed at all times except for the brief de-airing period.

The motion of the plate *B* can be brought about in a number of different ways. The important point is that the motion both up and down shall be positive. The machinery necessary to accomplish this need not be complex inasmuch as the movement is only a fraction of an inch and lasts for a brief interval.

IV. Results Obtained

When the entrapped air is eliminated, pressure cracking is also eliminated, while the density of the ware and its uniformity are greatly improved; its strength can be increased many times and clays otherwise unworkable can be made to produce good ware.

FIG. 2.—New device for assuring complete de-airing by the direct de-airing process. (*A*) Supporting or bottom plate of die pad; (*B*) plate which keeps openings in plate *C* clear for evacuation; (*C*) outside or pressure plate of die pad through which air is withdrawn from mold box of dry press.

[5] G. L. Dimitri and J. E. Delaunay, "Manufacture of Refractory and Insulating Products," U. S. Patent No. 1,374,493, April 12, 1921; abstracted in *Jour. Amer. Ceram. Soc.*, **4** [10] 865 (1921).

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DRAFT CONTROL AS A MEANS OF FUEL CONSERVATION IN KILN FIRING*

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Abstract

The importance of closely regulating the internal pressure of a kiln under fire is discussed from a standpoint of uniformity of heat treatment of the charge, reduction of fuel consumption, and efficiency in the use of combustible gases. An attempt is made at an analysis of the causes of low efficiency and high fuel consumption.

I. Introduction

By his book, Fundamentals and Economies in the Clay Industries,[1] Ellis Lovejoy prompted an investigation during 1935 of some of the basic facts and reactions connected with coal firing of heavy clay products in round downdraft kilns. This investigation covered (1) the literature and (2) kiln trials.

II. Theoretical Considerations

(1) Neutral Plane in a Kiln

If a round downdraft kiln were inverted and the crown vent holes stopped, the chamber could be filled with water only to the top of the furnaces. The surface of the water could be considered as the neutral plane. In a kiln the lighter gases tend to "float" upward into the portion of the kiln chamber above the tops of the furnaces and must be drawn downward by a negative pressure below the furnace tops where the pressure changes from positive to negative, *i.e.*, below the neutral plane.

(2) Secondary Air

The distillation of the hydrogen, hydrocarbon gases, and free carbon from coal progresses as air is drawn or forced through an incandescent bed of coal. The temperature at which this distillation progresses is around 2000° to 2500°F. In addition, it is necessary to add secondary air to complete the combustion and to maintain oxidizing conditions around the ware.

In most ceramic kilns, only cold air is available for secondary air which, if added in a sharp blast, chills as the blast contracts the unburned gases. Since some of the hydrocarbons will not ignite at temperatures much below that at which distillation has taken place, those that are difficult to burn progress through a charge of red-hot ware without burning and, therefore, do not serve as heat producers.

A sharp blast of cold air tends also to agglomerate free carbon particles, which agglomerates are slow to burn even with excess air present. The free carbon results in dense smoke that passes entirely through the kiln with resulting losses of fuel value. This forming of comparatively large particles of free carbon by cold-air blasts is due to the powerful electrical attraction of the carbon particles for each other. The cold air is nearly five times denser than the hot gases, thus bringing the free carbon particles closer together. The electrical attraction of the carbon particles for each other increases according to the inverse of the square of the distance between the carbon particles. The carbon particles in the cooler surrounding gases would therefore have an agglomerating influence nearly twenty-five times greater than that which exists at the distillation temperature, depending of course on the amount of dilution of the hotter gases by the cold air.

With hot secondary air, a "soft" lazy flame is obtained which is easily controlled to be either oxidizing or reducing, but with a cold air blast of secondary air it is impossible to burn the free carbon and the hydrocarbons completely, even with the presence of much excess air.

(3) Pressure in the Kilns

The difference in density of the outside air and inside gases creates a pressure on the gases in the top of the kiln. This pressure is balanced by the friction of the gases on the ware and by the losses of head due to directional turns through the ware. This pressure is available only down to the neutral plane, the level of which is dependent on the friction losses. If the movement through the ware is too rapid, the friction quickly balances the pressure above, the negative pressure plane below is much higher than the furnace tops, and the gases

* Presented at the Annual Meeting, American Ceramic Society, Columbus, Ohio, March 30, 1936 (Ceramic Ware Firing Symposium).

[1] Ellis Lovejoy, Fundamentals and Economies in the Clay Industries. ii + 361 pp. Randall Publishing Co., Wellsville, N. Y., 1935. Reviewed in *Ceram. Abs.*, **14** [9] 236 (1935).

must be pulled further downward. As this occurs, there is a less even level at the neutral plane because it is not possible to pull heated gases downward evenly except in an open unobstructed inclosure. The circulation tends to be greatest at the points of least frictional resistance.

NOTE: It is fortunate that at high temperatures much of the heating in the bottom, below the neutral plane, is done by radiation and conduction of heat from unit to unit or much of the ware would never be more than well warmed. The resistance of the clay body offers little resistance to the travel of radiant heat because the wavelength of such heat is so short that it readily penetrates even a solid body. This is evidenced by the rapid rise and fall of a protected thermocouple. It is certain that the temperature of the thermocouple tubes can not change nearly so rapidly as does the temperature of the gas.

If furnaces are fired "tight," thus building up the frictional resistance to the entry of secondary air, the pressure due to the greater density of the outside air can not build up the pressure over the top of the kiln charge and the neutral plane within the kiln charge is not lowered as it should be, and the bottom is sure to be unevenly heated.

The friction builds up against the passage of gases downward through the ware at the rate of the square of the velocity and only this compensating frictional force tends to even up the movement of gases below the neutral plane. In less restricted passages, the more rapid movement immediately builds up sufficient drag to balance part of the greater restriction elsewhere. This causes some movement of gases in the more restricted passageways.

(4) Radiant Heat

Another factor, seldom considered, which plays an important part in the efficient use of the heat from combustible gases is the relation of wavelengths to intensity of radiation for temperatures commonly attained in kilns.

The simple diatomic gases such as hydrogen, oxygen, and nitrogen do not absorb radiant heat over that required to raise their temperature, nor do they radiate appreciable amounts of heat. Carbon monoxide absorbs some heat besides its sensible heat, but not nearly so much as do triatomic gases such as water-vapor, carbon dioxide, and hydrocarbon gases of more complex composition. This heat, in addition to the sensible heat, is absorbed by the energy required to agitate the atoms, or it may be considered as the kinetic energy required to stretch or break up the molecular bonds as the temperature is raised. On cooling, the agitation subsides and the bonded atoms of the molecules contract and much radiant heat is thrown out. The radiant heat thrown off increases with the thickness of the gas layer up to about 40 feet.

In the air, there is no chemical combination or bond between the oxygen and nitrogen and other inert gases, and it is apparent that no extra heat can be obtained from the oxygen and nitrogen except as diatomic gases acting individually. An excess of air therefore is ineffective from the standpoint of carrying radiated heat, but anything done to increase the percentage of carbon dioxide and water-vapor adds to the uniformity of heating throughout the charge owing to the radiated heat carried. This is evidenced by the decrease of temperature differential from bottom to top of a kiln being fired during a rain storm or in weather of high humidity.

(5) Effect of Too Much Excess Air

The use of too much excess air tends to produce uneven heated bottoms as does tight firing. Excessive air, not required by the ware, adds to the volume of gases which must be forced downward by the pressure in the top of the kiln or moved downward by the draft. Since the friction head builds up rapidly with added velocity and added volume, the pressure head available is soon used up by friction, requiring that the gases below the neutral plane be exhausted by a higher negative pressure of the kiln stack or fan suction; *e. g.*, the volume of combustion gases with 180% excess air is 24% greater than with 140% air, and the friction is increased 60%.

NOTE: It is not uncommon to find kilns operating with 200 to 250% excess air.

If the friction head builds up sufficiently in the charge due to excessive velocity, the high negative pressure from below often causes the neutral plane to move upward above the bag wall. This results in a waste of heat because the high velocity of gas movement downward will be most largely at the outer edges of the kiln setting and not in the center.

NOTE: Past practice has been to raise the bag walls or to choke the side flues in the floors to prevent such short cutting of the gases, but a reduction of stack or induced draft, thereby reducing excess air, and the open firing of the furnaces to lower the neutral plane will tend toward the same end with great saving of fuel and much more evenly fired ware.

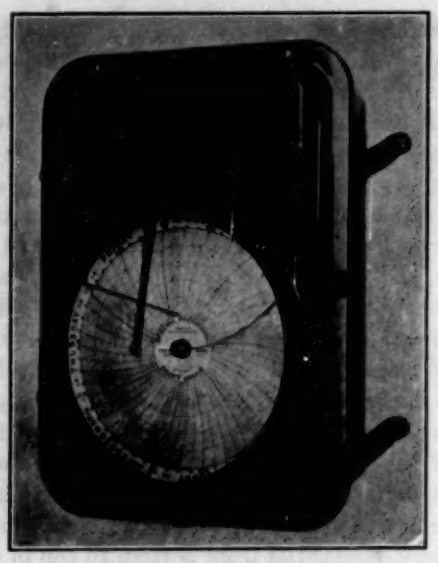

FIG. 1.—Portable-type recording draft gage.

III. Importance of Draft Control

That the minimum amount of excess air above that required for a correct atmosphere around the ware being fired be maintained, it is absolutely essential that an accurate and sensitive recording draft gage be used in such a manner that only negative pressure below the kiln floor be measured. This means that the intake into the gage-suction line must be installed where there will be no gas movement or at most a very slow movement of gases past its end; otherwise the reading recorded is not indicative of the true negative pressure on the kiln because velocity head would thus be added to the negative pressure head reading.

Firing the furnaces lightly, maintaining a draft just sufficient to advance the temperature at the desired rate, and having the throat of the furnace wide open obviously are the most effective means to "get the bottom" and not overfire "the top."

IV. Test Runs on 35-Foot Downdraft Kilns

(1) The Kilns

The 35-foot downdraft kilns of the Adel Clay Products Company[3] are operated by induced draft which pulls all heated gases through a radiated heat drier. Each of these kilns has twelve 30-inch Slater-type deadbottom furnaces with a sloping fireclay firing table. The fuel is fired lightly onto the table and sliced ahead just prior to each firing. The kilns have continuous flash walls instead of individual bag walls for each furnace. The kiln bottoms are those usually used in kilns for firing sewer pipe. They have a center well into which twelve spoke flues lead under an open floor. The center well has its outlet through a "blind" flue below the spoke flues leading to an underground tunnel serving all kilns in common. The exhaust fan is located at the cold end of the drier.

Every second furnace is fired so that two complete rounds of the kiln are required to fire all furnaces.

NOTE: This method of alternate furnace firing, as developed by the Bureau of Mines tests, eliminates smoke caused by the distillation of fuel upon the hot coals of the freshly fired furnaces.

(2) Draft

It was found that with light firing a draft of 0.09- to 0.11-inch negative hydrostatic pressure seemed to be the most economical, depending on the nature of the charge being fired, and that as little as 0.01-inch increased draft made a noticeable decrease in the uniformity of temperature between the top and the bottom of the kiln. Equipment was not available to determine the exact temperature difference, but an inspection hole in the bottom of the charge running across from door to door made it possible for an experienced fireman to notice easily some differences after a few hours of operation at a higher draft.

The special draft gage enables the fireman to regulate the draft to the proper reading.

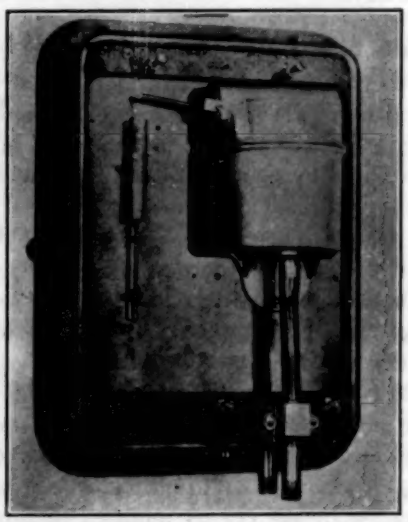

FIG. 2.—Inclosure of suction cup which is inserted in oil; the cup is suspended inverted from a primary lever arm.

V. Results Obtained with Proper Draft Control

(1) An average of cost per ton of ware fired showed a saving in fuel of 31.1 cents per ton of ware fired during four months after installation of the draft gage over the average cost during the four months just prior to the installation.

(2) The ware in the lower part of the kilns was much more uniformly hard and less ware was overfired in the top, especially around the furnaces.

(3) Fewer clinkers were formed and they were much more easily removed. Slagging of ashes on the furnace was greatly reduced and it is believed that kiln furnace repairs will be reduced at least 60%.

(4) The lower draft with less excess air volume to handle allowed a reduction of the speed of the induction fan with a saving of more than $100 per month for power required by the motor driving the fan.

(5) Less leakage into the flue system was evident because of the lowered suction developed by the slower induction fan speed and thus a higher temperature was attained in the radiant heat drier and better drying resulted.

(6) The lower suction of the induction fan allowed a higher humidity to be maintained in the drier because leakage into the radiating system was reduced and the moisture from the drying ware built up the humidity more nearly to the desired 65% found best in this particular drier.

References

(1) A. Schack, abstracted article on radiation, *Mech. Eng.*, p. 41 (Jan., 1925).

(2) Haslam, Lowell, and Hunneman, "Radiation from Luminous Flames," *Bull. Mass. Inst. Tech.*, Serial No. 123 (April, 1925).

(3) W. Trinks, Industrial Furnaces, Vol. I, 2d ed., appendix pp. 309–12. John Wiley & Sons, Inc., New York (1927); *Ceram. Abs.*, 7 [1] 45 (1928).

(4) W. E. Groum-Grjimailo, Flow of Gases in Furnaces. Tr. by A. D. Williams. John Wiley & Sons, New York (1927); *Ceram. Abs.*, 7 [1] 45 (1928).

(5) W. H. Walker, W. K. Lewis, and W. H. McAdams, Principles of Chemical Engineering, Chapters 3, 4, and 7. McGraw-Hill Book Co., Inc., New York (1st ed., 1923).

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MULLITE DEVELOPMENT IN SUPER-DUTY FIRECLAY BRICK*

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Abstract

Specimens of super-fireclay brick, fired to cones 11, 13, and 18, were compared to determine the amount of mullite developed. X-ray diffraction patterns of the three specimens compared with standard samples containing 40, 50, and 60% mullite indicated that all three specimens contained approximately 50% mullite. Petrographic examination showed distinct mullite crystals in the specimen fired to cone 18, while no mullite crystals could be identified in the specimen fired to cone 11. It is concluded that firing to higher temperatures than cone 11 increases the size of the mullite crystals but probably not the total amount of mullite present.

I. Introduction

This paper is concerned with the quantitative determination of the mullite content of samples of super-duty fireclay brick subjected during manufacture to firing treatments of three intensities.

Super-duty fireclay brick are tentatively defined by the A.S.T.M.[1] by the following properties: (*a*) P.C.E. not lower than cone 33, (*b*) alumina content not less than 40%, (*c*) loss in the panel spalling test not greater than 1.0%, and (*d*) linear shrinkage when reheated to 1600°C, not greater than 0.5%.

When the four classes of fireclay refractories, *viz.*, (1) high heat duty, (2) intermediate heat duty, (3) moderate heat duty, and (4) low heat duty, were set up a number of years ago, there was no necessity for a fifth division, since fireclay brick capable of meeting the above rigid specifications were not then obtainable. These extra-quality brick, introduced at the beginning of this decade, have become well established in a number of distinct types of service. Their extraordinary resistance to thermal shock and their exceptional volume stability at high temperatures sets them apart from the high-heat duty type of fireclay brick.

The performance of the super-duty fireclay brick has made necessary the revision of existing ideas concerning the correlation of such properties as porosity and spalling resistance. Formerly it was thought that a low spalling brick must have at least moderately high porosity, but some of the brick of this new class combine a degree of resistance to thermal shock, which would not have been hoped for a few years ago, with a very low porosity.

For the most part, the super-duty fireclay brick are fired only to cones 13 to 14, but others fired to cone 18, at an increase in works cost, have established a limited market in the glass trade and elsewhere. Since the differences between super-duty fireclay brick of cones 13 to 14 and cone 18 firing, as brought out by ordinary physical tests, are not of great magnitude, it was thought that a knowledge of their crystal development might give a fuller explanation of their behavior in service.

(1) Survey of Literature

Ross and Kerr[2] demonstrated that there are three distinct kaolin minerals (dickite, kaolinite, and nacrite), each having the formula $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$. As far as is known, kaolinite is the primary essential mineral in most United States fire clays. Nacrite is exceedingly rare, but the recent identification of dickite from a Pennsylvania coal mine warns against a closed mind. To sum up the present situation, the optical constants of the kaolin minerals have been established by the painstaking labors of Ross and Kerr, but the positive identification of the aluminum-bearing minerals in the various fire clays still remains largely unaccomplished. This work is complicated by the fineness of particle size and by the yet unfinished picture as to the prevalence of hydrous-aluminum silicates other than the three kaolin minerals. In this group are beidellite, montmorillonite, halloysite, and others. Halloysite has been identified in the flint clays from Missouri diaspore pits.[3]

Notwithstanding the care used by various workers in studying the dissociation of kaolinite and dickite when heated, there continue to be points of disagreement. A critical survey of the recent work, however, seems to indicate that there is not so much difference in observation as in interpretation.

On heating kaolinite and dickite, thermal effects are ob-

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[1] "Report of Committee C-8 on Refractories," *Proc. A.S.T.M.*, 35 [Part 1] 261 (1935).

[2] C. S. Ross and P. F. Kerr, "The Kaolin Minerals," *U. S. Geol. Surv. Prof. Paper*, No. 165-E (1931).

[3] V. T. Allen, "Mineral Composition and Origin of Missouri Flint and Diaspore Clays," *Biennial Rept. of State Geologist, Rollo, Mo.*, Appendix IV (1935).

served at about 550°C and at about 950°C. The first is an endothermic effect accompanying the dehydration of the mineral; since part of the water loss occurs over a considerable temperature interval this is not a sharp effect. At 950°C there is a sharp exothermic effect which has received various interpretations. The disagreement between various investigators is most largely an uncertainty concerned with the physical state of kaolinite in the temperature interval between the dehydration temperature and the range in which crystal structures are positively identifiable. Since the lower part of this temperature range is not of interest in evaluating the properties of the finished refractory (although as a works problem, it may be highly important), further discussion is not warranted here. All sides of the question are discussed by Sosman[4] and more recently by Insley and Ewell,[5] who, by studying natural dickite and kaolinite as well as gels of similar analysis, have developed data which it is hoped will lead to a better understanding of the disputed points or serve to remove them. Their data tend to refute the idea that dehydration of kaolinite results in the formation of a new compound, metakaolin. They have concluded that after dehydration the kaolinite becomes a mixture of amorphous alumina and amorphous silica. This condition persists up to the temperature of the exothermic effect (about 925°C).

The questions of greatest interest in connection with the present study concerned the development of mullite. At what temperature does it first appear when a clay is heated? The treatment necessary to develop the maximum percentage of mullite and the effect on crystal development of even further heating were also of interest.

In their investigation of the system Al_2O_3–SiO_2 which proved that there was only a single aluminum silicate stable at high temperatures (mullite, $3Al_2O_3 \cdot 2SiO_2$), Bowen and Greig[6] did little work to determine at what temperatures mullite is first found in kaolin minerals. By the addition of fluxes to mixtures of alumina and silica, however, they succeeded in growing mullite crystals at 1050°C.

By taking X-ray photographs of calcined clays held side by side with reference standards consisting of feldspar and artificial mullite in increments of 5%, Navias[7] obtained photographic films on which the upper lines represented the X-ray pattern of calcined clay and the lower lines represented the X-ray pattern of the reference mixture. By visual comparison of these patterns, he concluded that the "clays experimented with, whether ball clay or china clay, when fired to cone 10 (about 1300°C) develop in a crystalline form the maximum quantity of mullite which the alumina and silica present will allow."

With slight modifications, the X-ray methods used in the present study of super-duty fireclay brick were similar to those followed by Navias.

Riddle[8] prepared mixtures of kaolin and bauxite and traced by X-ray and petrographic methods the course of mullite development at various temperatures. He found mullite absent at 800°C, a single faint mullite line in the X-ray pattern at 1000°C (cone 05), and a strong development at 1200°C (cone 6). Higher temperatures up to cone 30 were studied, but the "most marked change appears to be between 1000°C and 1200°C."

Nahmias reported[9] that the dehydration product from a bauxite consisting of kaolinite and boehmite ($Al_2O_3 \cdot H_2O$) first gave mullite lines at about 950°C, above which temperature the mullite structure becomes more and more definite, and the complete mullite pattern is obtained at 1100°C.

Various clays heated by Posnjak and Greig[10] for 13 days at 1000°C gave lines identifiable as mullite in most cases, but too faint for positive identification in others. An interesting observation was that the strength and sharpness of the diffraction patterns varied greatly, depending upon the type of clay used. The best mullite pattern was given by a beidellitic type of clay from Silver City, Utah, and identification of mullite lines was most difficult in the two clays of kaolinite type.

In selecting the methods of studying mullite development for the present investigation, consideration was given to the work of several investigators who have separated the mullite by solution of the remainder of the calcined clay in hydrofluoric acid. This method has been successfully used in isolating mullite crystals for optical and X-ray study,[10] and attempts have been made at quantitative interpretation. Hydrofluoric acid, however, attacks mullite to a minor extent[11] and makes it difficult to obtain dependable quantitative data. Rieke and Schade[12] have derived a method wherein the isolated mullite is assumed to represent 80% of the total percentage present. Yoshioka[13] and his associates have used a similar method differing only in minor details, which they recommend, however, only for estimation purposes because of inaccuracies introduced by the slight solubility of mullite in hydrofluoric acid.

(2) Review of Work Cited

A reconsideration of the references reviewed in the foregoing pages as well as the data in other papers not dis-

[4] R. B. Sosman, "Equilibrium in System Alumina-Silica," *Jour. Amer. Ceram. Soc.*, **16** [1] 60–68 (1933).

[5] H. Insley and R. H. Ewell, "Thermal Behavior of the Kaolin Minerals," *Jour. Research Nat. Bur. Stand.*, **14** [5] 615–27 (1935); R.P. 792; *Ceram. Abs.*, **14** [8] 201 (1935).

[6] N. L. Bowen and J. W. Greig, "The System Al_2O_3–SiO_2," *Jour. Amer. Ceram. Soc.*, **7** [4] 238–54 (1924); [5] 410 (1924).

[7] Louis Navias, "Quantitative Determination of the Development of Mullite in Fired Clays by an X-Ray Method," *ibid.*, **8** [5] 296–302 (1925).

[8] F. H. Riddle, "Effect of Preparation and Calcination Treatment on Properties of the Kaolin-Alumina Mixtures Al_2O_3-SiO_2," *ibid.*, **15** [11] 583–97 (1932).

[9] M. E. Nahmias, "Second Symposium on Physical Chemistry of the Alumina-Silica Refractories: III, Bauxites and Mullite," *ibid.*, **16** [9] 420–21 (1933).

[10] E. Posnjak and J. W. Greig, "Notes on the X-ray Diffraction Patterns of Mullite," *ibid.*, **16** [11] 569–83 (1933).

[11] T. N. McVay, "Determination of Mullite in a Porcelain Body," *ibid.*, **10** [1] 62–63 (1927).

[12] R. Rieke and W. Schade, "Determination of Mullite Content of Porcelains by Chemical Means, etc.," *Ber. deut. keram. Ges.*, **11**, 427–42 (1931); *Ceram. Abs.*, **10** [5] 363 (1931).

[13] T. Yoshioka, T. Horie, and J. Karashima, "Mullite in Clay Refractories," *Jour. Soc. Chem. Ind.* [Japan], **37** [4] 171–72B (1934); *Ceram. Abs.*, **13** [11] 294 (1934).

cussed here indicate a surprisingly good agreement concerning the temperature at which an identifiable mullite pattern appears when clay minerals are heated. Mullite is not reported as having developed in such materials below 900°C, but its occurrence in samples heated at 1000°C and slightly below have been reported by several investigators. Insley and Ewell's data are particularly interesting since they apparently correlated incipient mullite development and the exothermic action noted at about 950°C in heating kaolinite and dickite. Using a two-junction thermocouple with one junction imbedded in a neutral substance and the second in the clay mineral, they found that the exothermic effect in the clay mineral began to be recorded at about 925°, as shown by the higher temperature of the thermocouple in the clay mineral. The difference between the two couples reached its widest spread at about 950°C, while at about 1000°C they came together again. The observations made by Insley and Ewell[8] on kaolinite and dickite heated at 6°C per minute through this range were as follows:

(1) Just before the beginning of the exothermic effect (925°C) the samples showed no X-ray pattern. (They believe that between the temperature of dehydration and 925°C, the dickite and kaolinite residues were mixtures of *amorphous* silica and alumina.)

(2) Samples quenched from the temperature corresponding to the peak of the exothermic effect (950°C) showed the X-ray pattern of γ-alumina.

(3) Samples quenched from a temperature just above the range of the exothermic effect (*i.e.*, at 1000°C, when the two thermocouples have just returned to the same temperature), showed X-ray patterns not only of γ-alumina but also of mullite.

Hyslop and Rooksby,[14] whose conclusions are not the same as those of Insley and Ewell, nevertheless give corroboration on the points of most interest in the present discussion; their X-ray patterns showed γ-alumina at 1000°C and other lines which they thought could have been either mullite or sillimanite; above 1060°C the mullite pattern was unmistakable.

Insley and Ewell's work showed further that extended preheating of kaolinite below the temperature range of the exothermic effect greatly diminished the magnitude of the effect; an accompanying observation was that the lines of γ-alumina were made to develop at temperatures as low as 875°C as a result of this preheating.

Most of the studies cited have had more direct bearing upon the temperature at which mullite formation begins than upon the heat treatment necessary for the complete development of the maximum percentage of mullite. The present investigation was concerned only with the latter point.

II. Method

(1) Preparation of Specimens

A small number of super-duty fireclay brick were prepared by regular works procedure. The brick were molded in the usual manner on a heavy-duty toggle press. There was probably little, if any, difference in composition between the various individual specimens. The batch of brick was divided into three lots for different firing treatment. The first lot was fired to cone 11, the second to cone 13, and the third to cone 18, all in works kilns. The maximum sustained temperatures were approximately as follows:

Cone 11	1280°C	(2336°F)
Cone 13	1320	(2408)
Cone 18	1430	(2606)

Physical tests were carried out on the three lots of specimens giving the following data:

Degree of firing	Cone 11	Cone 13	Cone 18
Apparent porosity	12.0%	11.8%	11.3%
Spalling loss (A.S.T.M. Panel Spalling Test)	1.0	0.7	0.1

Chemical analysis	(%)
Silica	51.8
Alumina + titania	45.3
Ferric oxide	1.3
Lime	0.5
Magnesia	0.3
Alkali	1.1
	100.3

(2) Test Methods

(*I*): The specimens were examined by means of the petrographic microscope by the usual methods (by C. R. Fettke, Carnegie Institute of Technology).

(*II*) (*a*) *Qualitative:* For the X-ray examination, the coarse grains from each of the three specimens were ground to a fine powder in an agate mortar. Each powder was mixed with a little Canada balsam and the paste was smeared on a fine copper wire. The wire and powder were then placed at the axis of the X-ray camera in such a way that the beam of X-rays after passing through a narrow slit impinged on the sample. During the exposure, the rays were diffracted by the sample and fell on a photographic film which was so mounted as to form the arc of a circle about the sample as center. The diffracted rays produced a line pattern characteristic of the material and of the copper wire carrying the powder. The positions of the known copper lines served as reference standards and as a calibration of the film against warping or other irregularities. The line separations, *i.e.*, the distance, in centimeters, of the lines from the zero line produced by the undeviated beam, were corrected by determining

[14] J. F. Hyslop and H. P. Rooksby, "Effect of Heat on the Crystalline Break-Up of Kaolin"; *Trans. Ceram. Soc.* [Eng.], **27**, 93–96 (1927–1928); *Ceram. Abs.*, **7** [10] 719 (1928).

the displacement of the copper lines from their theoretical positions. Intensities were estimated visually on an arbitrary scale of 1 to 10.

In order to convert the line separation into lattice plane spacings, it would be necessary to know the camera radius and the wave-length of the X-rays used. For the purpose of this investigation these constants were unnecessary as a comparison was being made between the line separation of the spectra produced by the specimens and the known spacings of pure mullite, quartz, cristobalite, and tridymite under identical camera and wave-length conditions.

(*II*) (*b*) *Quantitative:* In order to estimate the percentage mullite present in each specimen, it was necessary to build a new camera in which the X-ray diffraction pattern of the unknown was obtained under identical conditions with that of a sample of known mullite content. Figure 1 represents the arrangement used. After passing through the slit into the camera, the X-ray beam was divided by a thin lead (Pb) partition so that one half struck the unknown sample, A, and the other half the known specimen, B. Samples A and B were placed one above the other in a gelatine tube of uniform cross-section and separated by a thin wad of paper. The two samples were packed to the same density in order that the same weight of material would intercept each half of the X-ray beam. The photographic film was wrapped about four-fifths of the way around a drum attached to the lid of the camera. Two separate patterns were thus formed on the film, one on each side of the lead partition.

A series of samples of known composition was made up from intimate mixtures of powdered mullite and powdered Pyrex-brand glass. The mullite used was that described by Pole and Taylor[15] and gave the same X-ray pattern as a sample prepared by J. W. Greig of the Geophysical Laboratory in Washington. The Pyrex-brand glass gave no X-ray patterns. The series consisted of three concentrations by weight, *i.e.*, 40 mullite, 60 glass; 50 mullite, 50 glass; 60 mullite, 40 glass.

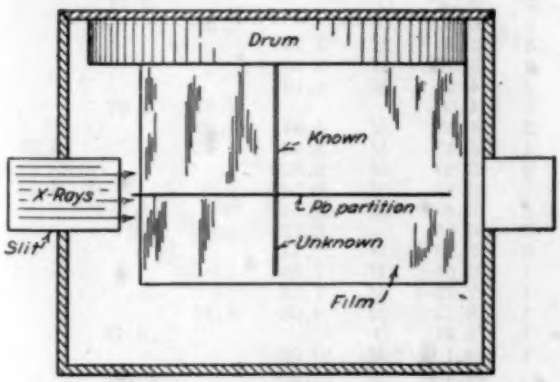

FIG. 1.

Relative intensities of the X-ray lines of the known and unknown specimens were estimated visually. The accuracy of the method was limited by the sensitivity of the eye in judging differences in intensity of corresponding lines. It was believed that differences in intensity produced by mullite variations of 5% or less would be hard to detect. For this reason only three standards, differing by 10% intervals, were used.

NOTE: The X-ray work was carried on by N. W. Taylor of the Ceramic Department of the Pennsylvania State College.

An attempt was made to obtain a more exact comparison of the intensities of the lines of the known and unknown specimens by Victor Hicks of the University of Pittsburgh.

A method of obtaining relative concentrations by making microphotometer curves of the X-ray photograms has been described by Clark and Reynolds.[16] This method was found, after a preliminary trial, to be unsatisfactory in the present investigation, owing largely to the high continuous background on the films.

III. Results

(1) Microscopic Examination

In thin section, the specimen fired to cone 11 showed fairly distinct boundary lines between the large flint clay particles and the matrix, *i.e.*, ground mass. There were occasional grains of residual quartz ranging in diameter between 0.08 and 0.16 millimeter. Some finer quartz particles, mostly less than 0.02 millimeter were visible in both the large clay particles and the matrix. No indications of mullite development were observed either in thin section or powder from this specimen.

In thin section, the specimen fired to cone 13 showed less distinct boundary lines between the flint-clay particles and matrix than that fired to cone 11. Quartz grains of about the same size

[15] G. R. Pole and N. W. Taylor, "Kinetics of Solid-Phase Reactions of Certain Carbonates with Mullite, Silica, and Alumina," *Jour. Amer. Ceram. Soc.*, **18** [11] 325–27 (1935).

[16] G. L. Clark and D. H. Reynolds, "Quantitative Analysis of Mine Dusts," *Ind. Eng. Chem., Anal. Ed.*, **8** [1] 36 (1936).

and number were found in both specimens. These show practically no conversion into cristobalite. No mullite crystals definitely recognizable under the microscope with the highest magnifications could be seen, but indications of incipient crystallization in the form of minute skeletal outlines were present.

In the specimen fired to cone 18, there was not much contrast between the flint-clay particles and the matrix. The outlines of the smaller particles had disappeared and the boundaries of the larger ones were not sharp. Only a few quartz grains remained. These represented the larger original grains and showed some alteration around their boundaries and along fractures. An interlocking mass of very fine mullite crystals of needle-like habit had developed in the larger flint-clay particles and in the matrix. They were just measurable with the micrometer eyepiece and were about 0.01 millimeter in length and 0.0007 millimeter in width.

(2) X-Ray Examination

(*a*) Tables I, II, and III show the line separations for the three specimens, together with the corresponding values for pure mullite, cristobalite, quartz, and tridymite:

TABLE I

CONE 11 SPECIMEN

(Copper K-radiation, 77 volts on transformer primary, 9 milliamperes tube current, 7 hours exposure)

(Line separations (cm.))

Intensity sample	*L* sample	Probable identity	*L* mullite (*M*)	*L* cristobalite (*C*)	*L* quartz (*Q*)	*L* tridymite (*T*)
2	1.67	*M*	1.66			
2	1.88	*T*				1.91
8	2.15	*M*	2.16	2.21	2.14	2.13
5	2.35	*M*	2.36		2.33	
7	2.63	*M*	2.64			
3	2.82	*C*		2.86		
5	3.10	*T* or *C*		3.14		3.08
5	3.34	*M*	3.35			
6	3.56	*M*	3.56			
3	3.70	*Q* or *T*			3.69	3.68
7	4.16	*M*	4.13			
3	4.54	*C*		4.51		
3	4.68	*C*		4.70	4.63	
5	4.88	*M*	4.84	4.89		
7	5.48	*M*	5.43	5.42		
4	5.82	*M*	5.82			
7	6.15	*M*	6.14			6.13
3	6.71	*M*	6.72			
2	6.94	*Q*			6.88	
4	7.11	*M*	7.14			
2	7.56	*M*	7.59			
3	7.76	*M*	7.73			
3	8.14	*T*		8.16		
2	8.49	*Q*			8.45	

TABLE II

CONE 13 SPECIMEN

(Copper K-radiation, 77 volts on transformer primary, 9 milliamperes tube current, 7 hours exposure)

(Line separations (cm.))

Intensity sample	*L* sample	Probable identity	*L* mullite	*L* cristobalite	*L* quartz	*L* tridymite
2	1.64	*M*	1.66			
2	1.70					
2	2.04	*C*		2.04		
7	2.22	*C*	2.16	2.21		
2	2.42	*T*				2.41
7	2.67	*M*	2.64		2.71	
3	3.19					
3	3.38	*M*	3.35			
4	3.60	*M*	3.56	3.64		
2	3.73	*M*			3.69	
4	4.15	*M*	4.13			
2	4.90	*C*		4.89		
1	5.68					
2	5.82	*M*	5.82			
5	6.13	*M*	6.14			6.13
2	6.50	*M*	6.51			
3	7.12	*M*	7.14			
2	7.60	*M*	7.59			
2	7.71	*M*	7.73			
2	8.42	*Q*			8.45	

Out of a total of 24 lines measured on the sample, 15 (62%) can be identified with *known mullite lines* (average deviation 0.02 centimeter). The other 9 lines can be identified with quartz, cristobalite, or tridymite.

Out of a total of 20 lines measured on the sample, 11 (55%) can be identified *with known*

TABLE III

CONE 18 SPECIMEN

(Copper K radiation, 77 volts on transformer primary, 9 milliamperes tube current, 7 hours exposure)

(Line separation (cm.))

Intensity sample	*L* sample	Probable identity	*L* mullite	*L* cristobalite	*L* quartz	*L* tridymite
2	1.65	*M*	1.66			
2	1.97	*Q*		2.04	1.94	1.91
4	2.19	*C*	2.16	2.21	2.14	2.13
2	2.38	*M*	2.36		2.33	
4	2.64	*M*	2.64			
3	2.74	*Q*			2.71	
2	3.20	*C*		3.27		
3	3.38	*M*	3.35			
3	3.57	*M*	3.56			
2	4.12	*M*	4.13			
1	4.56			4.51	4.63	
2	4.85	*M*	4.84	4.89		
4	5.46	*M*	5.43	5.42		5.51
2	5.80	*M*	5.82			
5	6.13	*M*	6.14			6.13
2	6.49	*M*	6.51			
2	6.65		6.72			
3	7.10	*M*	7.14			
1	7.61	*M*	7.59			
1	7.73	*M*	7.73			
1	8.12	*M*	8.08	8.16		
1	8.41	*Q*			8.45	
1	10.10	*M*	10.09			
1	10.40	*M*	10.39		10.32	
2	11.50	*Q*			11.55	

mullite lines (average deviation 0.02 centimeter). Six of the other 9 lines can be identified with quartz, cristobalite, or tridymite.

Out of a total of 25 lines measured on the sample, 17 (68%) can be identified *with known mullite lines* (average deviation 0.02 centimeter). Five of the other 8 lines can be identified with quartz, cristobalite, or tridymite. The number of lines attributed to quartz is rather surprising as cristobalite would be expected after a cone 18 firing. The petrographic examination, however, also showed some quartz grains remaining.

(*b*) Direct X-ray comparison of the three specimens with the series of standards of known mullite content gave the following results:

TABLE IV

(%) Standard	Relative intensities of mullite X-ray lines: Cone 11 specimen	Cone 13 specimen	Cone 18 specimen
60% mullite 40% glass	Weaker	Weaker	Weaker
50% mullite 50% glass	About the same	About the same (or a little stronger)	About the same
40% mullite 60% glass	Stronger	Stronger	Stronger

IV. Conclusions

Were we to depend upon the petrographic examination alone, we would be forced to conclude that the only specimen which contained mullite was that fired to cone 18. The X-ray tests show conclusively, however, that all three specimens contained mullite.

Calculation from the chemical analysis of the brick showed a theoretical content of mullite just slightly under 60%, on the assumption that all the alumina present went to the formation of mullite when fired. The data of Tables I, II, and III show that abundant mullite was present in all three specimens. The data in Table IV indicate that there is present in all three specimens studied slightly more than 50% mullite and that each specimen contains approximately the same percentage of mullite independent of the cone to which it was fired.

It is concluded that all of the mullite which will form was present in the specimen fired to cone 11. Firing to cone 18 increased the size of the mullite crystals but not the amount.

Acknowledgment

The authors wish to acknowledge the experimental work on which this paper is based by N. W. Taylor and C. R. Fettke and to express their appreciation of their careful work.

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DELAYED GROUND-COAT BLISTERING*

By G. H. Spencer-Strong and James J. Theodore

Abstract

Blistering is described and an investigation as to its causes is reported.

I. Introduction

Most enamel shops now and then encounter sieges of defects which are readily recognized and remedied, but occasionally a defect is encountered so unusual in nature and so mysterious of origin as to leave the enameler in a helpless state of mind. The present paper deals with the investigation of such a problem.

II. The Problem

The defect in question has never been definitely named, but for purposes of description may be called "delayed ground-coat blistering." It is not generally apparent in the ground coat or in the first cover coat, but it usually makes its appearance in the second cover coat in the form of deep broken blisters or blowholes which extend down to the steel. The walls and lips of the crater are lined with the ground coat, which serves to accentuate the defect.

In a plant where this defect was encountered in its most aggravated form, it was found to appear after the pickling acid was about three days old, with sulfuric acid, and after five to six days with hydrochloric acid. At the same time, a copper flash became apparent on the surface of the ware.

Inasmuch as the copper flash was the only unusual phenomenon apparent until the appearance of the final defect, the question arose as to what part it might play in the problem. The copper flash and the disappearance of the defect when new acid was used, as well as the depth of the blisters, indicated a pickle-room difficulty.

In view of these indications, a thorough study was made of the pickle room and its surroundings, and a laboratory investigation was planned.

The preliminary investigation disclosed (1) the presence, adjacent to the mill room, of a sand-blast room, in which steel grit containing considerable iron dust was used as an abrasive; the grit was found to be well scattered about the shop; (2) the use of a cleaner containing undissolved resin; (3) the use of an asphaltic liner in the acid tank, small particles of which were found in the acid; and (4) three possible sources for the copper, (*a*) faulty electrowelding, (*b*) brass rods in the acid tank too close to the acid, and (*c*) a rather high copper content in the enameling iron (which was not sufficient to cause the difficulty).

III. Method and Procedure

The laboratory investigation consisted, in brief, of four major parts, covering the main steps in the pickling process and the effects of steel grit.

(1) Pickling Solutions

Regular pickling solutions were used in all cases except those parts of the investigation requiring some change as noted in Table I. In the acid both 6% H_2SO_4 and 11% HCl were used during the course of the experiments. A double neutralizer, consisting of cold soda ash (1 pound to 60 gallons of water) and a boiling borax solution (1 pound to 30 gallons of water) were used.

(2) Copper Flash

Since the presence of the copper flash on the ware prior to the emergence of the defect was marked, it became necessary to perform each experiment both with and without the flash. The copper in each test was introduced into the pickling acid. With H_2SO_4 pickle, it was introduced as $CuSO_4$, while with HCl pickle, a heavily oxidized copper plate was introduced into the acid along with the plates being pickled. Metallic copper plated out on the iron as a result of electrolytic action. It was found that a copper concentration in the acid, equivalent to from 0.015 to 0.03%, was required to give this flash. The 0.015% gave a light flash, while 0.03% gave a fairly heavy coating. The weight of coating is noted in Table I. There was little difference in the results obtained except that the $CuSO_4$ gave a more easily controlled flash.

(3) Steel Grit

Twenty-mesh steel grit, containing a considerable amount of fine dust, was used for blasting. Unpickled plates were blasted in a laboratory

* Presented at the Annual Meeting, American Ceramic Society, Columbus, Ohio, April 1, 1936 (Enamel Division).

TABLE I

COMPOSITE TABLE OF RESULTS OF EXPERIMENTS WITH DELAYED GROUND-COAT BLISTERS

Expt. No.	Pickling treatment: Cleaner	Acid	Neutralizer	Copper* (%)	Blasting treatment	Results
A–1	Prepickled			None	Grit with dust	Some blisters
A–2	Regular	Regular	Regular	0.03	" " "	Numerous blisters
A–3	"	"	"	0.015	" " "	Many (not as many as A–2)
A–4	"	"	"	None	" " "	Some blisters
A–5	"	"	"	0.015	Grit with no dust	No defect
A–6	"	"	"	None	" " " "	" "
A–7	"	"	"	0.03	None	" "
A–8	"	"	"	None	Gouged and hammered	" "
A–9	Prepickled			"	" " "	" "
A–10	Regular	Regular	Regular	0.015	" " "	" "
B–1	"	"	"	0.015	Iron dust rubbed in	" "
B–2	Iron dust	"	"	None	None	" "
B–3	" "	"	"	0.015	"	" "
B–4	Regular	"	"	0.015	Graphite rubbed in	" "
B–5	Graphite	"	"	None	None	" "
B–6	"	"	"	0.015	"	" "
B–7	5% rosin	"	"	None	"	Some blisters
B–8	" "	"	"	0.015	"	" "
B–9	Hard water	"	"	None	"	" "
B–10	" "	"	"	0.015	"	" "
C–1	Regular	10% $FeSO_4$	"	None	None	No defect
C–2	"	" "	"	0.015	"	" "
C–3	"	30% "	"	None	"	" "
C–4	"	" "	"	0.015	"	" "
C–5	"	Asphaltic tank liner	"	None	"	Some blisters
C–6	"	" " "	"	0.015	"	Numerous blisters
C–7	"	Lead chloride	"	None	"	No defect
C–8	"	" "	"	0.015	"	" "
D–1	"	Regular	1/3 weakened	None	"	" "
D–2	"	"	" "	0.015	"	" "
D–3	"	"	2/3 "	None	"	" "
D–4	"	"	2/3 "	0.015	"	" "
D–5	"	"	Neutralized	None	"	" "
D–6	"	"	"	0.015	"	" "

* 0.03% indicates heavy coating; 0.015%, light coating.

sand-blast machine[1] and were subjected to a normal pickling treatment. The fine dust was separated from the grit and the plates were blasted with the dust-free grit. Iron dust was also introduced into the cleaner and the acid. In an effort to determine whether or not the defect was being caused by acid or dirt trapped in the abraded surface, plates were gouged with a sharp file, and the pits and scratches resulting were partially closed by hammering. In some cases, iron sulfate was tamped into these holes and the holes were hammered shut. This was done on both the pickled and the nonpickled plates.

(4) Cleaner

A commercial-type cleaner free from free rosin was used, and the temperature was carried at the boiling point. Cleaner experiments included the introduction of iron dust, free powdered rosin (5% of the amount of cleaner), and graphite with very hard water. The laboratory water has a hardness of 62 parts of $CaCO_3$ per million; this was increased to 800 parts per million.

(5) Acid

The iron sulfate content of the acid was increased to 10 and 30%. Lead chloride was added to hydrochloric-acid pickle to determine whether or not lead might be deposited on the iron and cause trouble. Asphaltic tank liner was finely ground and suspended in the acid.

(6) Neutralizer

To determine whether or not improper neutralization might be a factor in the problem, the double neutralizer was combined into a single tank and acid was added in such amount as to reduce the strength of the neutralizer to one-third, two-thirds, and to destroy it entirely.

[1] G. H. Spencer-Strong, "Some Experiments in the Development of a Sand-Abrasion Machine," *Jour. Amer. Ceram. Soc.*, **19** [4] 112–15 (1936).

(7) Miscellaneous

Plates were rubbed with graphite and with iron dust and were pickled to determine whether or not mechanical contamination of unpickled ware in the boxes might have some effect.

IV. Data and Results

Table I shows the tests made and their results. The latter are given in terms of the delayed blistering defect only, since it is obvious that certain of the treatments would produce other defects. To simplify tabulation, the data have been classified under four heads as follows:

Class	General type of experiment
A	Steel grit
B	Cleaner
C	Pickling acid
D	Neutralizer

Since the miscellaneous tests are similar in nature to some of those shown in class B, they have been included under that heading.

The data of Table I indicate the presence of the defect in ware which has been pickled and then blasted with grit containing fine dust and also where the sample plates were first blasted and then pickled. Plates blasted with the dust-free grit do not show the defect. The presence of a copper flash aggravates the trouble, the heavier flash showing the more aggravated defect. Plates gouged by hand do not show the trouble, nor do those in which ferrous sulfate has been trapped. Copper flash alone causes no trouble.

Iron dust and graphite rubbed on the plates and placed in the cleaner do not cause any trouble. Free rosin and hard water, both with and without copper flash, caused the defect. The blisters were smaller in these cases than those caused by blasting with steel grit and by the asphaltic tank liner.

In the acid experiments, the asphaltic tank-lining compound gave rise to the defect and again the copper flash appears to have aggravated the condition. None of the other experiments with acid or cleaner gave rise to this specific defect.

V. Conclusions

(1) The presence of a copper flash is not conducive to enameling defects if unaccompanied by other contributing factors.

(2) Where factors are present which give rise to delayed ground-coat blistering, a copper flash will aggravate the defect.

(3) The blistering tendency was noted in plates which had been blasted with steel grit containing fine dust and in plates which had been pickled in acid containing particles of an asphaltic tank-lining compound.

(4) Free rosin in the cleaner, even though the cleaner be boiling, caused the blisters both with and without the copper flash.

(5) The use of very hard water in the cleaner and the subsequent deposition of insoluble calcium soaps on the ware gave rise to the defect.

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SOLUBILITY CHARACTERISTICS OF GLASSES BASICALLY DIFFERENT IN COMPOSITION*

By W. C. Taylor and R. D. Smith

Abstract

Comparative results are given using the American Ceramic Society No. 1 powder method on several glasses representing lime, lead, and borosilicate compositions. The effect of temperature on the rate of attack and some comparisons of surface attack to the powder method are given.

I. Introduction

The No. 1 powder method[1] tests showed very good agreement between the several coöperating laboratories in the comparison of two samples of lime glass. From the work done, it would appear that this method might be satisfactory for lime glasses. It seemed advisable, however, to obtain data on other glasses to see whether the method would be of general application.

Briefly, the No. 1 powder method calls for the treatment of 10 grams of glass powder of 2.5 density and of 40- to 50-mesh screen size (0.417 to 0.295 millimeter) in 50 cubic centimeters of $N/50$ H_2SO_4 for four hours at 90°C, measuring the amount of alkali liberated from the glass into this standard acid solution.

II. Glass Chosen for Tests

Six glasses were chosen, including two borosilicates, two lime, and two lead glasses, of approximate compositions given in Table I.

Table I

	A (%)	B (%)	C (%)	D (%)	E (%)	F (%)
SiO_2	81	73	72	63	35	60
R_2O_3	2	1	1	1		3
Na_2O	4	17	13	7		8
K_2O				7	7	
B_2O_3	13					29
CaO		5	9			
MgO		3	5			
PbO				22	58	

These six glasses appear satisfactory as to durability under the respective service conditions to which each glass is subjected.

III. Test Methods Investigated

Certain modifications were made to the No. 1 method to study the effect of temperature and of the extracting solutions, $N/50$ H_2SO_4, water, and $N/50$ NaOH. Since the powder method expresses the alkali extracted in terms of percentage of Na_2O, assuming a soda-lime glass of density 2.5, it was necessary to adjust the weight of glass used to conform with equivalent areas when using glasses differing materially from 2.5 density.

Methyl red indicator was used in place of phenol red so that CO_2 would not interfere in the case of water and alkali extractions and low-temperature acid extractions.

The figures (average of at least two determinations) given in Table II represent grams of Na_2O extracted from approximately 7000 square centimeters of surface. In some cases, five or six determinations were made to determine the probable error. For instance, the values for glass A with water at 90°C were 0.00116, 0.00099, 0.00136, 0.00081, 0.0010, and 0.0011. The average 0.0011, if taken from two determinations, would be accurate to about ±0.0002 for the lower values.

The results are sumarized in Table II and Fig. 1.

Table II

Glass	A	B	C	D	E	F
Wt. of Sample (g.)	8.92	10	10	11.4	16.92	8.93
Solvent: g. Na_2O/7000 cm.[2] Temperature 90°C						
$N/50$ H_2SO_4	0.0047	0.0689	0.0205	0.137	0.221	0.371*
H_2O	.0011	.0482	.0220	.0410	.0015	.165
$N/50$ NaOH	.0062	.0516	.0220	.0228	.0127	.0944
Temperature 40°C						
$N/50$ H_2SO_4	.0037	.0127	.0077	.0193	.185	.169
H_2O	.0012	.0088	.0042	.0069	.0015	.0098
$N/50$ NaOH	.0027	.0055	.0048	.0041	.0046	.0136
Temperature 25°C						
$N/50$ H_2SO_4	.0033	.0089	.0054	.0108	.123	.0923
H_2O	.0009	.0059	.0032	.0040	.0017	.0052
$N/50$ NaOH	.0012	.0058	.0025	.0039	.0039	.0060

* All acid used in extraction and excess required.

(1) Acid extraction gives values different from those given either by alkali or water extractions.

(2) The use of acid in place of water causes

* Presented at the Annual Meeting, American Ceramic Society, Columbus, Ohio, March 31, 1936 (Glass Division). Received July 13, 1936.

[1] Anon., "Report of the Committee on the Chemical Durability of Glass," *Bull. Amer. Ceram. Soc.*, **14** [5] 181–84 (1935).

extreme changes in the order of solubilities of the six glasses. The use of $N/50$ alkali in place of water, on the contrary, causes no change in the order of solubilities of the glasses.

(3) The effect of glass dissolved is far less than would be anticipated considering the corrosive nature of $N/50$ alkali, and apparently alkali extraction is the major factor under the conditions of these powder methods.

(4) The order of solubility of the two soda-lime glasses, B and C, does not change regardless of the reagent used. The increased difference in solubility with the use of the acid reagent may be

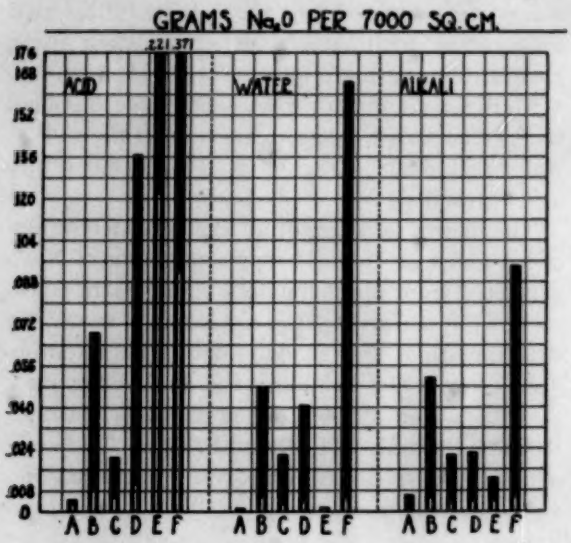

FIG. 1.—Values at 25°C shown by double lines; values at 90°C are solid black.

cited as an advantage in comparing these two glasses as long as the same order of solubility is maintained.

(5) The two lead glasses, D and E, would appear entirely unusable by the No. 1 method as it is. With water or alkaline extraction, glass E appears in both cases to be superior to either B or C, and glass D would fall in between B and C with water and equal to C with alkali.

(6) The borosilicate glass, A, shows up well in any comparison, but glass F is definitely better by comparison with alkaline solution than with acid. Glass F is also decidedly affected by temperature and does not look so bad at 25°C but would be considered unsatisfactory at 90°C.

(7) In general, the comparison of the 25°C temperature extraction for 4 hours with the 90°C extraction shows that the rate of acceleration with temperature is quite different in the case of each of the six glasses.

(8) The selection of the 4-hour treatment at 90°C appears to be justified in that approximately 70% of the attack which would occur in a 10-hour period has progressed in 4 hours under the temperature conditions of the test according to Thomas[2] and Burch.[3]

IV. Rate of Alkali Extraction

With soda-lime glasses there is little doubt that the accelerated results are comparable with room-temperature results over a considerable time of exposure to water. It seemed desirable, however, in comparing the other glasses, to determine the rate of extraction of alkali into water at 25°C for periods of from 1 to 72 hours. Glasses A, B, C, and F were tested in this manner and the results are reported in Table III.

TABLE III

Glass	Alkali-Na_2O extracted by water at 25°C				
	10 min.	1 hr.	2 hr.	4 hr.	72 hr.
A	0.00075	0.00105	0.00093	0.0009	0.00167
B		.0044	.0048	.0059	.0140
C		.00266	.00273	.0032	.0065
F		.00105	.00130	.0052	.0233

(1) These data show that glasses differing basically in composition liberate alkali at differing rates according to the time of exposure to water.

(2) It does not seem to be important at which time interval the extraction values from the two soda-lime glasses, B and C, are compared, but duration of extraction is of major importance when the borosilicate glasses, A and F, are compared either as to extraction values, one with the other or with glasses B and C.

(3) The two borosilicate glasses, A and F, show the greatest variation, owing to duration, in alkali-extraction values.

V. No. 1 Powder Method vs. Loss-in-Weight Method

It will be shown that the solubilities of some of these glasses as measured by loss of weight in $N/50$ acid, water, and $N/50$ NaOH are not in the order shown by the powder-extraction method.

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[2] M. Thomas, "Determination of the Durability of Glass by the Powder Method," *Jour. Soc. Glass Tech.*, **12**, 87–97 (1928).

[3] O. G. Burch, "Development of a Reliable Method for Determination of Solubility of Soda-Lime Glasses," *Bull. Amer. Ceram. Soc.*, **13** [8] 200–204 (1934).

Glass A was compared with glass B_1, a soda-lime glass similar in composition to glass B, as to loss in weight per unit area in the reagents $N/50$ H_2SO_4, water, and $N/50$ NaOH. The comparison of the values obtained for loss in weight with those obtained by the powder method using the three reagents is given in Table IV.

TABLE IV

	90°C—4 hr. No. 1 powder method (g. Na_2O/7000 cm.²)			90°C—100 hr. Loss-in-weight method (g. glass/100 cm.²)		
	$N/50$ H_2SO_4	Water	$N/50$ NaOH	$N/50$ H_2SO_4	Water	$N/50$ NaOH
Glass A	0.0047	0.0011	0.0062	0.00167	0.00184	0.0326
Ratio	4.27	1.0	5.64	0.9	1.0	18.6
Glass B_1	0.0594	0.0434	0.0401	.00164	0.00502	0.0517
Ratio	1.36	1.0	0.92	.33	1.0	10.5

(1) Glass A has a weight loss per unit area in the three reagents, $N/50$ H_2SO_4, water, and $N/50$ NaOH, of 0.9, 1.0, and 18.6, respectively; whereas the respective relationship by the powder method is 4.27, 1.0, and 5.64.

(2) Glass B_1 gives a loss-in-weight relation of 0.33, 1.0 and 10.5 in the acid, water, and alkali reagents, while the alkali extracted indicates a 1.36, 1.0, and 0.92 relation as shown by the powder method.

(3) The apparent explanation for this discrepancy is that the alkali is extracted through a residual film of glass which offers more or less resistance to continued extraction. This resistance depends upon the original glass composition and the reagent used in extraction of the alkali. A residual film resistant to the reagent used will cause the rate of alkali extraction to decrease with time in a manner characteristic of the glass and reagent used under the particular conditions of the test. The resistance of this film appears to be reduced by the use of acid in place of water, some glasses being affected much more than others by the substitution of reagent.

VI. Fogging Test

Glasses A, B, B_1, C, D, E, and F were subjected to a so-called fogging or clouding test. The original washed-glass shapes were placed in a glass container, the cover having an inlet and outlet opening so that air may be continually passed through the container. The jar with the glass sample contents was placed in an oven at 80°C and the air stream was passed through water for a time, followed by passage through a dehydrating chamber. In this manner the glass shapes were alternately subjected to air of extremely low moisture content and to the moisture content of air saturated at room temperature, the entire test being conducted at 80°C for 165 hours. The moist air exposure was for 33 hours and the dry air for 132 hours. All glass samples were of tubing shape with the exception of glasses B and C, which were taken in bottle and plate form, respectively, as received from the Bureau of Standards. Samples were placed against a black cloth background and were checked for fogged or hazed appearance.

(1) Glasses A, C, and F were definitely freer from fogging than were glasses B, B_1, D, and E. Glass E was next in order, with glass D intermediate to E and B.

(2) There was little difference between glasses B_1 and B, which were the most severely fogged glasses of the group.

(3) Glass F, which shows up poorly in all the powder tests, is one of the best in the fogging test. Glass E, which is poor using the acid reagent in the powder test, is quite good in the fogging test, and glass D, which the acid reagent shows to be relatively poor in stability by the powder method, is found to be decidedly better than glasses B_1 and B by the fogging method.

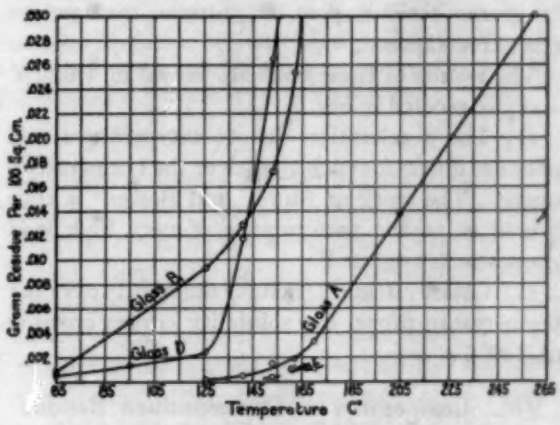

FIG. 2.

VII. Effect of Higher Temperatures

For further data on the effect of temperature, comparative solubilities were obtained on four glasses, A, B_1, D, and E, using a range of temperatures from 65° to 265°C, with distilled water in a sealed glass tube, subjecting the inner tube sur-

TABLE V

TEST TUBES SEALED WITH REDISTILLED WATER IN SEALED STEEL TUBES CONTAINING WATER TO EQUALIZE PRESSURE

(Area exposed approximately 40 square centimeters; residue in grams calculated to 100 square centimeters as weighed in a platinum dish after 6 hours at temperature and pressure.)

Glass	25°C	65°C	95–96°C	20 lb.	40 lb.	60 lb.	80 lb.	100 lb.	205°C	260°C	265°C
A				0.0002	0.0005	0.0017	0.0020	0.0034	0.0128	0.0301	
				.0000	.0005	.0012	.0020	.0039	.0147		
				.0005	.0005	.0015	.0020	.0027			
					.0007		.0015	.0032			
				.0002	.0005	.0015	.0019	.0033	.0138	.0301	
Av.											
B_1	None	0.0009	0.0051	.0096	.0132	.0155	.0255	.0346			
	"	.0009	.0047	.0089	.0125	.0189	.0252	.0337			
Av.	"	.0009	.0049	.0093	.0129	.0172	.0254	.0342			
D		.0006	.0013	.0024	.0106	.0305	.0535	.0928			
		.0005	.0013	.0026	.0127	.0225	.0582	.1013			
Av.		.00055	.0013	.0025	.0117	.0265	.0554	.0971			
E						.00050		.0010			.0138
						.00025		.0012			
Av.						.0004		.0011			.0138

face to the water for six hours at the desired temperature and weighing the residue from the extraction of the inner glass tube surface in a platinum dish after gentle ignition of the residue. To prevent breakage of the glass tubes at high temperatures and pressures, they were placed in cap-sealed metal tubes so filled with water as to equalize pressures. The solubility was expressed in grams residue per 100 square centimeters glass area exposed.

The results of these tests are shown in Table V and also plotted in Fig. 2.

(1) The acceleration due to temperature and pressure differs for each glass over the temperature range. The work of Morey and Bowen[4] is confirmed as to the performance of very high lead glasses such as glass E.

(2) Glasses B_1 and D behave differently over the temperature range, the solubility curves crossing at 140°C.

VIII. Composition of Decomposition Residue and Parent Glass

Some of the glass residues were analyzed to determine the extent of glass decomposition and the relation of the glass residue to the parent glass. Table VI gives the comparison of the residue in grams per 100 square centimeters and the calculated glass decomposition as obtained by analysis of the silica in the residue or by estimation of the alkali. All values were obtained from 170°C extractions.

[4] G. W. Morey and N. L. Bowen, "Decomposition of Glass by Water at High Temperatures and Pressures," *Jour. Soc. Glass Tech.*, 11 [42] 97–106 (1927); *Ceram. Abs.*, 6 [10] 428 (1927).

(1) Lead glasses D and E give residues less representative of the true glass compositions, the very high lead glass, E, retaining its protective film to a greater extent than glass D. At lower temperatures glass D behaves well, but at 125°C the rate of attack increases abruptly.

(2) Glasses A and E behaved well in the powder method when water was used as the reagent at temperatures 25°C and 90°C, indicating that the protective film persists at these temperatures. The low slope of the curves showing the extracted residues from the glasses also confirms the resistance of the films up to 150°C for both of these glasses. Above that temperature there is an acceleration in attack, the greater in the case of glass A.

TABLE VI

Glass	Residue (g./100 cm.²)	Glass decomposition as calculated: By SiO_2 determination (g. glass/100 cm.²)	By alkali determination (g. glass/100 cm.²)
A	0.0033	0.00336	
B_1	.0342	.0470	0.0700
D	.0971	.1820	.3400
E	.0011	(K_2CO_3: no SiO_2 found)	

IX. Effect of Protective Film

To determine the effect of the protective film under static and erosive conditions, tubes of glass A and glass E were made into condensers. They were subjected to escaping steam for 100 hours, and the tubes were weighed before and after the test. Under these conditions glass E lost 13 times as much as glass A.

X. Conclusions

(1) Results obtained by the American Ceramic Society No. 1 method on six different commercial glasses do not give a correct indication of the general usefulness of a glass and in fact would be misleading even if restricted to weathering or acid or alkali solubility.

(2) Certain modifications of this method, however, might be made which would give a better indication of the general usefulness of these glasses.

(3) It may be impossible to obtain any single test which will measure the general durability of glass, owing chiefly to the fact that durability is too broad a term and different type glasses vary decidedly in durability according to the solvent used, the temperature, and the particular conditions which may influence protective deposits or removal of products of decomposition. This being the case, it will be necessary either to specify tests for different types of service or to devise some method whereby more than one sample of the glass is tested under more than one set of conditions.

(4) The American Ceramic Society No. 1 method is satisfactory only for lime glasses. Further work will be necessary before a more general method can be adopted.

Acknowledgment

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Corning Glass Works
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STRENGTH AND PHYSICAL PROPERTIES OF FINE GLASS FIBERS AND YARNS*

By Games Slayter

Abstract

Glass fibers have been produced in large quantities running from 0.0007- to 0.00005-inch fiber diameter. The strength of individual fibers and the strength of yarns produced from these fibers have received preliminary investigation. Some of the strengths obtained are quite remarkable, running into the order of $1^1/_2$ million pounds per square inch. Even these strengths fall short of the theoretical possibilities. Some possible reasons and explanations are discussed.

I. Introduction

A glass strand, 5040 miles long without a break, has been prepared composed of 60 filaments, each filament having a diameter of 0.00025 inch and a tensile strength of approximately 250,000 pounds per square inch. The diameter of the strand is 0.0067 inch and its strength per square inch is 17,350 pounds. The strength per square inch of the strand, based on the sum of the area of the 60 filaments, is 247,000 pounds.

II. How Glass Strands Are Made

To prevent the glass fibers from injuring each other by scratching, a small amount of lubrication is necessary (ordinarily about $1^1/_2\%$). When this lubricant is fumed on, $^1/_{10}$ of 1% is sufficient.

In the manufacture of yarn, these strands are combined; sometimes two and sometimes ten strands are twisted together to form thread. Two or more of the threads so formed are then twisted together in a reverse direction. When so combined, there is no kinking of the finished thread. From this point, the thread is handled as any other textile material. In most cases a liberal percentage of lubrication is left on the fiber until the finished article has been made, after which it is washed out with soap and water.

It was thought at first that the lubrication might contribute something to the strength of the glass, but on repeated tests, it was found that individual strands have identical strengths with or without lubrication. Lubrication merely prevents one fiber from scratching and thus weakening the other. If the lubrication is evenly distributed over all of the surfaces, a layer of one or two molecules in thickness is sufficient to accomplish this purpose, but practically, it is very difficult to apply this uniform distribution, necessitating a minimum of $1^1/_2\%$ lubricant.

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* Presented at the Annual Meeting, American Ceramic Society, Columbus, Ohio, March 31, 1936 (Glass Division).

III. Glass Cords

A cord composed of 3840 filaments is made up by first twisting four of the fine strands, each of which contains 60 filaments, into a thread. Four of these threads are combined to make a coarse thread, and four of the coarse threads are combined to make a cord.

The breaking strength of such a cord is 23 pounds; the diameter is 0.043 inch; and the strength is 16,200 pounds per square inch. Based on the total area of the strands making up the cord, the strength is 122,000 pounds per square inch.

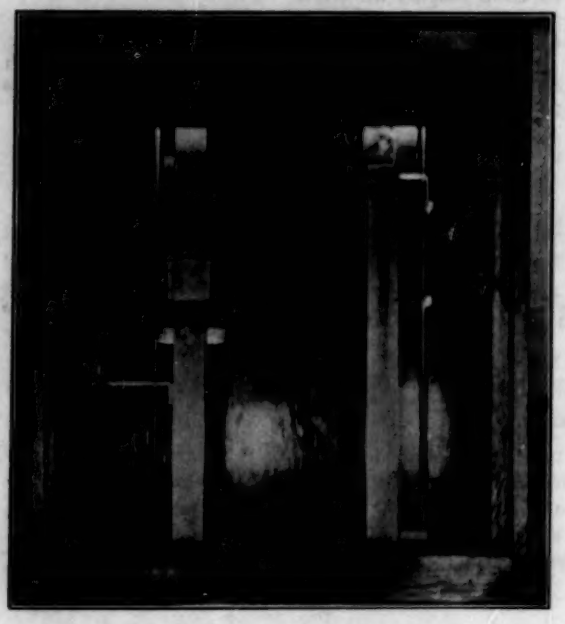

FIG. 1.—Chain-o-matic device.

The strength of the individual strand composed of 60 filaments is equal to the sum of the strength of the individual fibers. The thread composed of 960 filaments twisted together has a strength of about 75% of the sum of the individual strengths of the fibers incorporated. A cord made of four such threads twisted together has a strength which is 50% of the sum of the strength of the individual filaments.

IV. Testing Fiber Strengths

The use of the Chain-o-matic device, developed for testing the strength of these fibers (shown in Fig. 1), has reduced the scatter on fiber of uniform quality from about 50% to about 25%. The results obtained by other means were not consistent.

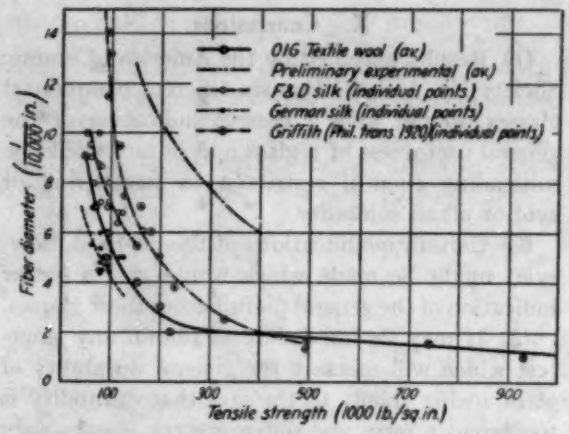

FIG. 2.—Tensile strength of fibers as a function of diameter.

Figure 2 shows various strengths obtained from the literature and from tests. The line to the left shows results obtained on German glass silk by the bucket method; the second curve from the left was obtained by Plummer[1] by the bucket method; each point on the curve represents the average of about 50 measurements.

The strength goes up very rapidly as the fineness of the fiber goes below 0.0002 inch. Plummer tested one group of fibers running approximately 0.00005 inch and obtained a point, not shown on the chart, at 1½ million pounds per square inch.

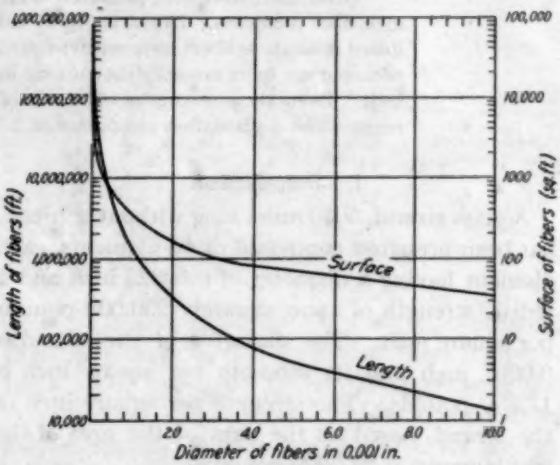

FIG. 3.—Total length and surface in one pound of glass wool of various diameters.

The fourth curve from the left is the result obtained by Griffith.[2]

[1] J. H. Plummer, Research Staff, Owens-Illinois Glass Company.

[2] A. A. Griffith, "The Phenomena of Rupture and Flow in Solids," *Phil. Trans. Roy. Soc.* [London], **221A**, 163 (1920).

The curve to the right represents data recently obtained by Anderegg using the Chain-o-matic device.

V. Chemical Composition Not a Controlling Factor

The manipulation of the fiber in the manufacturing process is the controlling factor in developing maximum strengths. The chemical composition of the glass, within the group of glasses which have been worked thus far, does not seem to affect the strength.

VI. Surface and Length per Pound

Figure 3 was prepared by Plummer, in which he has plotted on one curve the length and on the other the surface per pound of glass fiber against the diameter of fibers in thousandths of an inch. For instance, reading on the curve as to length, a fiber 0.0002 inch in diameter has a length of somewhere around 23 million feet per pound or in terms of miles, 4356 miles, and a total area of about 1500 square feet or 0.034 acre.

This indicates how important the happenings at the surface are to the manufacture and treatment of these fibers. The ratio of surface to weight has increased so tremendously over that in ordinary glass articles that the chemical and physical characteristics commonly attributed to glass are completely altered. Chemical attack or surface disintegration which would mean nothing in ordinary glass articles becomes of primary importance.

Owens-Illinois Glass Company
Toledo, Ohio

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November, 1936

15—11

Abrasives

Artificial grinding agents in the tool industry. Fritz and Kremer. *Oberflächentech.*, **13** [13] 159–64 (1936).—Injuries to health by dusts in grinding and polishing processes are discussed, and statistics for compensation paid in German industries are given. Contrary to general views, wet grinding gives rise to the most serious injuries to the lungs. According to present experiences, grinding disks with mineral binders can compete satisfactorily with natural sandstones. Magnesium oxide compounds as grinding material are conducive to reducing dust in grinding shops and lessen the danger of silicosis. M.H.

Buffing and polishing of architectural ornamental fixtures. R. A. Huhn. *Metal Cleaning & Finishing*, **8** [6] 347–48 (1936).—Polishing of ornamental metal fixtures requires a machine with facilities for changing the spindle speed to obtain the correct peripheral speed on the buffing or polishing wheels. It must be unusually adaptable to fit the many variations in work of this nature. One such machine is described in detail. E.J.V.

Comparative tests of the polishing actions of metallic oxides. U. Haberland, P. Neubert, and M. Werner. *Glastech. Ber.*, **14** [2] 60–66 (1936).—An experimental polishing machine is described which permits good reproducibility of results. Thirty types of iron oxide were studied. A synthetic oxide was found to be superior to the natural mineral, and there is a possibility of developing polishing compounds much superior to those in use. G.R.S.

Exhaustion of dusts in grinding shops. R. Tiquet. *Oberflächentech.*, **13** [15] 175 (1936).—Exhaust systems are discussed, and formulas are given for calculating the selection and installation of power. M.H.

Metal polishes. Ralph H. Auch. *Soap*, **12** [5] 28 (1936).—Abrasives commonly used in metal polishes are tripoli, silica, diatomaceous earth, precipitated calcite, and colloidal clay; rottenstone, emery flour, pumice, putty powder, precipitated chalk, whiting, tin oxide, salt, aluminum oxide, fuller's earth, and rouge may also be used. In general, the only value of colloidal clay consists in its ability to hold active abrasives in suspension. Formulas are given which illustrate the particular suitability of abrasives for any particular type of polish. M.J.H.

Polishing and polishing materials. R. Tiquet. *Galvano* [Paris], No. 48, pp. 17–19 (1936); abstracted in *Chem. Zentr.*, ii, 526 (1936).—Aluminous abrasives and the adjustment of abrasive disks are discussed in detail. M.V.C.

Polishing wheel cement. Arthur A. Kuecken. *Metal Cleaning & Finishing*, **8** [7] 422 (1936).—A new polishing wheel cement having a liquid bond which can be used to vary or control the density of the solution at the time of application is described. This new cement hardens under heat instead of softening as do the older types of cement. Friction heat causes it to become brittle so that new surfaces of the abrasive grains are exposed by its cracking. While it is not necessary to dry the wheels by heating, the setting can be hastened by drying the wheels at about 120°. E.J.V.

Practical application of polishing grain. Henry R. Power. *Metal Cleaning & Finishing*, **8** [7] 423–26 (1936).—The relation of particle size, capillarity, surface tenacity, particle shape, and crystal structure of abrasive grains to their practical application in polishing is given. E.J.V.

Scientific production of buffing compounds. L. R. Eastman. *Metal Cleaning & Finishing*, **8** [8] 495–99 (1936).—The production of modern buffing compositions

at the plant of Frederic B. Stevens, Inc., Detroit, Mich., is described in detail; the control exercised from the receipt of the raw material to the finished product is shown. E.J.V.

Scouring powders. RALPH H. AUCH. *Soap*, **12** [6] 32 (1936).—The percentage of abrasives in different scouring powders examined microscopically ranged from 70% to 92.6%. The requirements for efficient abrasive materials for use in cleansers are uniformity in texture and particle size, hardness, and sharpness. The shape of individual particles is an important factor insofar as the value of a material as an abrasive is concerned. The most important abrasive materials used in cleansers are silica, feldspar, and pumicite, feldspar being the most widely used. M.J.H.

PATENTS

Abrasive wheel. CARBORUNDUM CO. Brit. 451,781, Aug. 26, 1936 (June 9, 1934).

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Block for sectional grinding wheels. F. C. PENNY (Bridgeport Safety Emery Wheel Co., Inc.). U. S. 2,051,618, Aug. 18, 1936 (Oct. 16, 1934).

Cam grinding apparatus. C. G. FLYGARE (Norton Co.). U. S. 2,053,866, Sept. 8, 1936 (July 23, 1935).

Granular coated article and method of making. J. B. AUST (Carborundum Co.). U. S. 2,050,992, Aug. 11, 1936 (Nov. 22, 1933).

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Grinding or polishing attachment. ALFRED HOFMANN (Alfred Hofmann Needle Works, Inc.). U. S. 2,052,137, Aug. 25, 1936 (June 20, 1934; March 9, 1935).

Grinding tool for extremely hard alloys. PHILIPPE VOEGELI-JAGGI (Diamantschleiferei Vogeli & Wirz A.-G.). U. S. 2,051,558, Aug. 18, 1936 (Aug. 2, 1933). A composition of matter comprises diamond granules, manufactured abrasive granules of a hardness less than 10 on Moh's scale, graphite, and resin, the ingredients being thoroughly intermingled and hardened by the application of heat and pressure.

Grinding or tool-sharpening machines. A. H. STEVENS (Sundstrand Machine Tool Co.). Brit. 452,060, Aug. 26, 1936 (June 4, 1935).

Grinding wheel. CARL KRUG. U. S. 2,050,850, Aug. 11, 1936 (March 30, 1934). A grinding tool combines a solid annulus of granular texture, a ring of greater strength in the annulus provided with a uniformly smooth circumferential surface, the annulus and ring being secured together by a layer of cement forming a rigid connection between the annulus and the ring, a circular support, and radially extending clamping flanges associated with the support to embrace the ring.

Hydraulically operated grinding machine. H. A. SILVEN (Norton Co.). U. S. 2,053,878, Sept. 8, 1936 (July 12, 1935).

Knife-sharpening mechanism. HENDRIK STUKART (U.S. Slicing Machine Co.). U. S. 2,052,365, Aug. 25, 1936 (June 9, 1934).

Manufacture of rubber-bonded abrasive articles. W. J. TENNANT (Carborundum Co.). Brit. 451,236, Aug. 12, 1936 (Feb. 1, 1935).

Means for sharpening knives. INDUSTRIE A.-G. ALLEGRO. Brit. 451,091, Aug. 12, 1936 (Feb. 11, 1935).

Method of making abrasive wheels. NORTON GRINDING WHEEL CO., LTD. Brit. 451,641, Aug. 19, 1936 (Feb. 19, 1935).

Method of manufacturing abrasive-coated articles. R. C. BENNER AND R. L. MELTON (Carborundum Co.). U. S. 2,053,360, Sept. 8, 1936 (Dec. 23, 1933). A method of making abrasive-coated articles consists in the essential steps of sprinkling loose abrasive grains having individual nontacky films of a plasticizable binder onto a flexible moving web, plasticizing the films whereby a portion of the binder on each grain flows to the base of the grain and into contact with the web, and hardening the plasticized binder to cause the grains to adhere to the web, the films of binder on the grains being substantially all the binder applied to the article.

Method of manufacturing abrasive-coated fabrics. R. C. BENNER AND R. L. MELTON (Carborundum Co.). U. S. 2,053,361, Sept. 8, 1936 (Oct. 6, 1934).

Pulp grinder temperature control system. C. D. DE MERS (Taylor Instrument Co.). U. S. 2,050,749, Aug. 11, 1936 (July 25, 1933).

Sanding, polishing, and finishing machine. K. E. EDWARDS. U. S. 2,050,295, Aug. 11, 1936 (Feb. 27, 1936).

Sharpening mechanism for slicing machines. JOSEPH FOLK (U. S. Slicing Machine Co.). U. S. 2,052,367, Aug. 25, 1936 (April 2, 1934).

Sickle grinder. W. J. BORST (Deere & Co.). U. S. 2,051,071, Aug. 18, 1936 (May 14, 1934).

Slicing machine knife guard and grinding mechanism. A. H. AHRNDT AND JOSEPH FOLK (U. S. Slicing Machine Co.). U. S. 2,052,366, Aug. 25, 1936 (April 2, 1934).

Art and Archeology

American ceramics in Denmark. ANON. *Bull. Amer. Ceram. Soc.*, **15** [9] 320 (1936).

Cost of brickmaking in pre-Christian Egypt. SAMUEL ANGUS. *Sydney Morning Herald*, Aug. 15, 1936.—The Deissmann collection of ostraka, which has now been acquired for Sydney (N.S.W.) Univ., contains an ostrakon in Greek of the 3rd Century B.C. on brickmaking in the Fayum. It runs, "To brickmakers for 13,000 bricks, 2600 drachmas; to porters, 500 dr.; to a moulder, 250; for 24 bundles of straw, 360; for 2 masons, 1400; for 2 laborers, 100 dr." (The allusion to making brick with straw should be noted.) H.H.S.

Ostraka: Deissmann collection goes to Australia. SAMUEL ANGUS. *Sydney Morning Herald*, Aug. 8, 1936.—

The collection of Adolf Deissmann, of Berlin, has been acquired for Sydney Univ. by the generosity of Robert W. Gillespie. The collection consists of 90 Greek ostraka ranging in date from the 3rd Century B.C. to the 3rd Century A.D. It has been described in the book, Ostraka der Sammlung Deissmann, by Paul M. Meyer (Berlin, 1916). H.H.S.

Revives ceramic art. ANON. *New York Times*, Sept. 8, 1936.—The Chinese Government, in an attempt to revive the native ceramic art and industry, is regulating the digging of the special clays used for fine porcelains. M.V.C.

BOOK

Art in Everyday Things. ROYAL SCOTTISH MUSEUM, Edinburgh. H. M. Stationery Office, London, 1936. 68 pp. Price 4d. This is a catalog of the exhibition of Scottish Everyday Art, held in Edinburgh, May to Aug., 1936. H.H.S.

PATENTS

Decalcomania paper and transfer. F. W. HUMPHNER (Mid-States Gummed Paper Co.). U. S. 2,050,795, Aug. 11, 1936 (May 4, 1935).

Designs for:

Ashtray. W. E. MACKELFRESH, JR. (Owens-Illinois Glass Co.). U. S. 101,131, Sept. 8, 1936 (July 15, 1936).

Bottle. E. W. FUERST (Owens-Illinois Glass Co.), U. S. 101,032, Sept. 1, 1936 (July 22, 1936). G. A. MENGLE (Brockway Glass Co., Inc.), U. S. 101,132, Sept. 8, 1936 (Aug. 1, 1936). GEORGE SMITH, JR. (Olean Glass Co.), U. S. 101,144 and 101,180 to 101,182, Sept. 8, 1936 (Aug. 4, 1936).

Candelabrum. W. E. MACKELFRESH, JR. (Owens-Illinois Glass Co.). U. S. 100,870, Aug. 18, 1936 (July 11, 1936).

Condiment shaker. J. H. FUNKEY (Carr-Lowrey Glass Co.). U. S. 100,996, Aug. 25, 1936 (July 3, 1936).

Cup. R. G. COWAN (Onondaga Pottery Co.). U. S. 100,850, Aug. 18, 1936 (Oct. 18, 1935). U. S. 100,852, Aug. 18, 1936 (April 27, 1936).

Plate. M. E. BIRD (Wallace China Co., Ltd.), U. S. 100,844, Aug. 18, 1936 (June 12, 1936). R. G. COWAN (Onondaga Pottery Co.), U. S. 100,851, Aug. 18, 1936 (Feb. 13, 1936). B. N. KANE (Stetson China Co.), U. S. 100,778, Aug. 11, 1936 (May 28, 1936). GEORGE WESP (Continental Ceramics Corp.), U. S. 101,153, Sept. 8, 1936 (Jan. 6, 1936).

Cements

Calculation of exothermic effect during Portland cement formation by means of the composition of fired clinker. H. E. VON GRONOW AND H. E. SCHWIETE. *Zement*, **24** [35] 542–45 (1935).—Required data are formation heats of the lime silicates at 20°C and specific heats of these silicates up to 1300°C. Clinker formation necessitates a temperature above 1400°C but results are practically exact. Formation heats at 20°C are determined by dissolving components and compound in an acidic solution at 20°C. The calculation of a cycle between 20 and 1300°C gives for β-$2CaO{\cdot}SiO_2$ a formation heat, at 1300°C, of 25.35 cal./mol. Other clinker minerals, such as $3CaO{\cdot}SiO_2$ and $3CaO{\cdot}Al_2O_3$, are determined in the same way. All results are tabulated. If clinker is cooled slowly an analysis is sufficient to calculate the exothermic effect. In quickly cooled clinker, there remains a potential energy due to nonequilibrium which should be deducted from the exothermic effect. Other corrections are necessary, Al_2O_3 not being free in the batch; the decomposition of metakaolin liberates 14.5 cal./mol.; SiO_2 from metakaolin is uncrystallized (correction +7.2 cal./mol.). Examples of clinkers with slags are also discussed. F.E.V.

Cements for flooring. C. F. MASON. *Chem. Industries*, **38** [5] 508 (1936).—The recent and rapidly progressing tendency to use artificial flooring materials necessitates due consideration of the bonding agents by which they are affixed to their foundations. Various formulas for such cements are given. M.J.H.

Distribution of compounds in Portland cement. J. ARTHUR SWENSON AND E. P. FLINT. *Jour. Research Nat. Bur. Stand.*, **17** [2] 261–76 (1936); R.P. 910. Price 5¢.—Thirteen cements were separated into size fractions by means of air elutriation, and chemical analyses were made on all of the fractions and the whole cements. The compound compositions were calculated according to the method of Bogue (*Ceram. Abs.*, **9** [7] 499 (1930)) and plotted by two methods to show how the compounds are distributed with respect to size of particles. Heats of solution and hydration were determined for the fractions of five cements which were of very similar chemical composition and yet were known to differ considerably in certain physical properties. Studies of the observed heats of solution of the fractions of these cements as compared with the theoretical heats of solution indicated discrepancies between the true compositions and the calculated compositions. The results of microscopic examination of etched sections of the cement clinkers gave further indication of the existence of such discrepancies. R.A.H.

Effect of sodium hexametaphosphate on cement. R. T. THOMSON. *Analyst*, **61**, 320–23 (May, 1936).—$Na_6P_6O_{18}$ is known to have a solvent action on Ca and Mg compounds such as occur in boiler scale, the equation being $Na_6P_6O_{18} + CaSO_4 = CaNa_4P_6O_{18} + Na_2SO_4$. The effect on Portland cement was studied by digesting in the cold with an aqueous solution containing $1^1/_2$ times as much $NaPO_3$ as would theoretically dissolve all the CaO and MgO in the cement. After shaking 30 to 40 min., the cement became disintegrated, and SiO_2 was thrown suddenly out of solution. The mixture was further digested for 20 hr., filtered, and analyzed. Soluble, insoluble, and total components were, respectively, CaO 58.41, 6.36, 64.77%; MgO 0.20, 0.74, 0.94%; SiO_2 10.85, 11.60, 22.45%; Al_2O_3 none, 4.15, 4.15%; Fe_2O_3 none, 1.60, 1.60%. Iron Portland cement treated in the same way showed a difference in the solubility of CaO, MgO, and SiO_2, as follows: CaO 36.96, 21.17, 58.13%; MgO 0.71, 1.40, 2.11%; SiO_2 4.35, 19.25, 23.60%; Al_2O_3 none, 9.14, 9.14%; Fe_2O_3 none, 2.60, 2.60%. H.H.S.

Electrically heated furnaces for making plaster. C. H. S. TUPHOLME. *Ind. Eng. Chem., News Ed.*, **13** [22] 441

(1935).—The production of plaster in Switzerland in electrically heated furnaces is described in detail. Electrically heated furnaces and coal or oil-fired furnaces for the production of plaster are compared with respect to heat transmission, ease and cost of operation, and quality of plaster produced. F.G.H.

Hydration heats of cements. O. KALLAUNER AND B. BÜRGL. *Chem. Listy*, p. 238 (1934).—A certain direct difference exists between the maximum values of temperatures and the ascertained hydration heats during the hardening of cement in three days; therefore the results obtained through a simple measuring of the thermal course of the hardening of the cement may be used for an approximate, informative estimation of the hydration heats, not only in the course of setting but also at the time of the first setting of the cement. R.B.

Method for analyzing cement. N. A. TANANAEV. *Trudui VI Vsesoyuznogo Mendeleevskogo S'ezda teoret. prik. Khim.*, **2** [2] 379–80 (1935); abstracted in *Chem. Zentr.*, ii, 1226 (1936). M.V.C.

Specific heat of raw clay for cement manufacture. H. E. SCHWIETE AND H. E. VON GRONOW. *Zement*, **24** [13] 197–99 (1935).—Values of the specific heat of clinker given by White were checked and found correct up to 1300°C. The authors measured, in a mix calorimeter, the specific heats of pure components found in the raw materials. Figures are given, in some cases up to 1400° or 1500°C, for $CaCO_3$, CaO, kaolin, metakaolin, granulated slag, and SiO_2. The analysis of raw clay should be simplified, *e.g.*, Al_2O_3 is wholly attributed to kaolin, the remaining SiO_2 is supposed to be quartz, etc. Impurities in limestone may be neglected, for their specific heat is practically the same as that of $CaCO_3$. An example is fully treated. F.E.V.

Synthesis of hydrated monocalcic silicates under pressure. JEANNE FORET. *Compt. Rend.*, **203** [1] 80–83 (1936).—This silicate occurs naturally in the hydration of cements. It has been produced synthetically in an autoclave at 180° to 200°C from CaO and SiO_2 in equal parts. The hydrate obtained has the formula $SiO_2 \cdot CaO \cdot 0.25H_2O$. The crystal water content changes with the temperature under which the silicate is formed. A table is given for it between 130° and 190°C. M.H.

Thermal constants of setting concrete. H. SHEARD. *Proc. Phys. Soc.* [London], **48** [3] 498–512 (1936).—The rise in temperature in a large mass of concrete during setting may be considerable, and the shrinkage stresses induced by the subsequent cooling may become large enough to cause cracking. It is therefore important to be able to calculate the rise of temperature likely to occur in such mass. The calculation of the temperature rise requires a knowledge of the thermal constants of the material. Methods have been developed whereby measurements of the thermal conductivity and the thermal diffusivity of setting (fresh) concrete can be made. The thermal conductivity was determined on coaxial cylinders (heat flow), and the diffusivity was determined by means of observations on the rapid cooling of a cylindrical specimen. Results are quoted for typical concrete specimens, and the values (in tables and diagrams) of conductivity and diffusivity are compared with those for dry concrete. L.E.T.

PATENT

Process for the simultaneous production of pig iron and Portland cement. ERNST KARWAT (Union Carbide and Carbon Corp.). U. S. 2,052,879, Sept. 1, 1936 (Feb. 4, 1935). A process for the simultaneous production in a blast furnace of pig iron and Portland cement comprises feeding with the coke, as an integral part thereof, sufficient lime to form with the coke ash a slag of cement composition, the amount of lime so fed being a minor proportion of the total basic flux fed in the charge.

Enamel

Accounting for porcelain enameled products: VII. CHARLES S. PEARCE. *Enamelist*, **13** [6] 25–26 (1936).—When a new product is contemplated for a plant the development expense must be taken into consideration and distributed to the cost of the product. The items of development might include design, drawings, experimental work, models, tools, rearrangement of plant layout, special furnace tools, and special handling equipment. Division of the development cost over an estimated total production of the product is suggested. For Part VI see *Ceram. Abs.*, **15** [4] 116 (1936). E.J.V.

Additions of quartz and clay to the mill. VIELHABER. *Emailwaren-Ind.*, **13** [27] 225–26 (1936).—The tendency of clay to shrink on drying and its effect on enamels is discussed. The extent of shrinkage depends first on the granulation of the clay and then on the amount of water present. Although fine enamel particles act as thinning media on the shrinkage, their effect is insufficient. Quartz expands at 570°C because of transformation and in this way counteracts shrinkage of the mass. During the transformation quartz grains split and they are more easily dissolved by the enamel melt. The effect of suspending media is also mentioned. M.V.C.

Adherence of enamel to metal. W. O. *Emailwaren-Ind.*, **13** [32] 262–63 (1936).—An analysis of the latest American and German studies of the causes of adherence of enamel to metal is given. M.V.C.

Adjusting ground enamel. H. TROST. *Emailwaren-Ind.*, **13** [19] 161–63 (1936).—It was found that ground enamel adjusted with a borax solution crystallized and became more condensed than that without borax. To obtain a ground enamel containing borax which can be more easily applied, more water must be added, but the enamel becomes too liquid and its coating capacity is lowered, creating a flaky appearance. Storing the enamel is not recommended; it must be adjusted shortly before working. M.V.C.

Books on enameling. ANON. *Bull. Amer. Ceram. Soc.*, **15** [9] 320 (1936).—The Educational Bureau of the Porcelain Enamel Institute has published four booklets; Handbook on Design of Metal Parts for Porcelain Enameling, No. 1, Reflectance Test for Opaque White Porcelain Enamels, Porcelain Enameled Signs, and Sales Manual for Porcelain Enamel. These may be obtained without charge.

Borax problem in the manufacture of enamels and

glazes. F. H. ZSCHACKE. *Keram. Rundschau*, **42** [52] 644–45 (1934).—A shortage of foreign raw materials in Germany is a motive to spare borax. Borax is used to facilitate fusibility, decrease the coefficient of expansion, secure chemical stability, and prevent devitrification. It is difficult to substitute other fluxes, alkalis giving strong expansion and lead oxide being poisonous. Low-expansion constituents, silica and alumina, raise the softening point. Z. concludes that it is advisable to reduce borax content in some cases but complete replacing is impossible without lessened quality. Borax should be manufactured in German works buying foreign raw materials. F.E.V.

Breaking of ironware from pickling. FR. *Emailwaren-Ind.*, **13** [15] 131–32 (1936).—The breaking of ironware because of pickling is due to the absorption of hydrogen by the iron and the removal of the oxide layers adhering to the surface of the iron piece. This hydrogen absorption is catalytically promoted by impurities always present in traces in the iron. M.V.C.

Care and upkeep of cleaning solutions. V. D. SMITH. *Enamelist*, **13** [8] 6–7 (1936).—A preliminary boiling of the cleaning solution prior to use is advocated. In cleaning work to be porcelain enameled, the principal material to be removed is the lubricant and foreign matter that accumulates on surfaces from handling or special operations. As these materials are not acid in nature, cleaning loss through chemical change is very slight. Daily titration of the cleaning solutions for free and total alkalinity is necessary for an accurate check on the strength and efficiency of the solution. Variations in the nature of the material to be removed make it impossible to set any definite standard for minimum alkali readings. Sources of mechanical loss of solution are cited. E.J.V.

Causes of "boiling defects," specks, and pores in sheet-iron ground. H. LANG. *Glashütte*, **66** [12] 215–17; [13] 237–39 (1936).—There are too many technical expressions to designate enamel defects, with the result that the same defect is called by various terms. In the so-called boiling defects, the enamel does not melt well and it seems to have solidified suddenly. The enamel becomes very brittle and does not adhere well in such places. Experiments showed that these defects may be ascribed to (*a*) a too-long refining of the enamel, (*b*) incorrect mill additions and too fine grinding, (*c*) disproportionate thickness of the enamel coat, and (*d*) inappropriate firing. Specks are due to (1) the quality of the sheet iron, (2) incorrect pickling, (3) inappropriate calcining of the raw ware, (4) unsuitable ground enamel, (5) organic materials contained in the enamel or sheet iron, (6) effect of furnace gases when firing ground enamel, and (7) incorrect treatment and drying of the ground-coat enamel. According to experiments by L., pores belong to the same type of defects as specks. Pores appear in thick coats and specks in thin coats. This is the important difference between the two defects, while their different appearance is produced only by the different thickness of the enamel coat. Methods for eliminating these defects are mentioned. M.V.C.

Cleaning steel prior to enameling. WILLIAM J. BALDWIN. *Metal Cleaning & Finishing*, **8** [7] 429–34; [8] 465–68 (1936).—Cleaning is regarded as the entire operation necessary to obtain absolutely clean ware free from grease and scale which, when enameled, will give a perfect enameled product. In the cleaning operation the various stages are as follows: (1) cleaner, a hot solution that removes grease and oil from enamel shapes; (2) rinse, hot water; (3) pickle, acid solution (muriatic or sulfuric) to remove scale; (4) rinse, hot water; (5) neutralizer, a borax or borax-soda ash solution; (6) drier. Each step is discussed in detail. Tanks used for pickling may be of wood, lead-lined wooden tanks, acid-resisting brick, Monel metal, or rubber-lined steel tanks. Pickle baskets are generally made of Monel metal. Among special cleaning processes are (1) the second cleaner tank, used directly after the acid rinse, to remove any grease or oil that may have been protected by the scale; (2) the nickel dip to give the steel a fine coating of nickel to increase the adherence of the ground-coat enamel and to give a better finish to the fired ground coat; (3) the use of sodium cyanide in the neutralizer to prevent formation of insoluble iron precipitates in the ordinary neutralizer; and (4) automatic pickling. E.J.V.

Combining castings and weldings. T. S. QUINN AND JOHN HOWE HALL. *Ind. & Welding* [Second Quarter], pp. 51–54 (1936).—Foundry shops are being called upon to supply the increasing demand for castings to be assembled by welding into a finished structure combining cast and rolled sections. For complicated structures, casting usually is the cheaper process as it involves no expensive cutting of parts as for welding. The weakest parts of castings and welds are apt to occur in similar places such as change in cross-section. Cast steel of 0.20 to 0.30 C is considered as easily welded as rolled structural steel. Several examples of cast-weld assembly are illustrated. W.H.B.

Degreasing plant. HERBERT MORRIS, LTD. *Ind. Chemist*, **11**, 499 (1935).—Ware is degreased in trichlorethylene vapor by being conveyed on trays operated by an electric hoist block. By pressing a "jigging button" the tray is lifted 6 in. and lowered 6 in. automatically and continuously until the push button is released. H.E.S.

Determination of the quality of fusion welded joints. E. R. FISH. *Welding Jour.* [New York], **15** [7] 19–21 (1936).—Knowledge of the exact results of operators' efforts in welding through qualification tests, including physical and X-ray tests of welds, is stressed as necessary for procedure control. Older welded pressure vessels are entirely lacking in procedure control, and many have been found unsafe to use when investigated by cutting out the cylindrical coupon across the weld. After fabrication, it is recommended that the final item of inspection include coupons from a predetermined number of feet of welded joints to test the weld quality and holes in a vessel plugged with a threaded plug. W.H.B.

Determining pores in enamel. HANS EDNER. *Glashütte*, **66** [19] 333–34 (1936).—The advantages of the electrical method of determining pores of Hecht and Oldenburg (*Keram. Rundschau*, **43**, 263 (1935)) over the chemical method of Dawihl ("Standardization—" *Ceram. Abs.*, **15** [9] 270 (1936)), which is very slow with small pores and often inaccurate, are discussed. M.V.C.

Development of pickling plants. OTTO FOGEL. *Glashütte*, **66** [14] 251–52 (1936).—A brief historical review is given of the development in pickling technique. M.V.C.

Effect of the composition of cast iron on enameling. M. SIEBERT. *Glashütte*, **66** [17] 301–303 (1936).—The quality of cast iron is very important for the success of the enameling process. Requirements for Fe are as follows: (1) it must be thinly liquid when melted so that the casting of pieces is easy; (2) it must be finely granulated and have a dense structure; and (3) it must be low in oxides. The amount of shrinkage and expansion are important. Carbon as iron carbide is harmless, but it is harmful as free graphite; its maximum content must not exceed 3.6%. The graphite content must not exceed 83 to 85% of the total carbon content. The effect of a uniform change of the carbon content is discussed on the basis of the studies of Krinitzky. Not only the amount of graphite, but also the dimensions of graphite flakes are of great importance for successful enameling. M.V.C.

Enamel chipping on rims and how to prevent it. R. ALDINGER. *Keram. Rundschau*, **43** [3] 25–28 (1935).—Chipping of rims and curved parts is due to different causes. The best way to keep the defect within narrow limits consists in employing sheets of required thickness and in the control of raw materials and manufacturing processes. The expansion of enamels suitable for rims should be lower than that of iron but not so low that it produces a strong pressure in the enamel; the margin of expansion coefficient is rather limited. Chipping on rims may be attributed to the enamel itself, to the enameling process, or to design of the ironware. The ground coat obtains an adequate expansion by diffusion of iron oxide; the cover coat may have too small an expansion and chip frequently. In such a case the composition should be altered. It also happens that the defect disappears for a long time and then recurs; control of raw materials (weights, composition of feldspar, fineness of milling) is then necessary. Lack of adherence of the ground coat should be corrected. The rim enamel should be kept particularly thin, and the rim must be dressed with hot iron; still better is the absence of dressing. The sheet iron must be sufficiently thick to prevent deformations. Closed rims (full circle in cross-section) are best; small holes must be bored at the bottom of the circle. Open rims should have at least ¾ of a circle in cross section. Careful control of rims of ironware must be maintained. F.E.V.

Enamel paintings. VIELHABER. *Emailwaren-Ind.*, **13** [29] 242–43 (1936).—A brief review is given of methods used to produce enamel paintings in the U.S. M.V.C.

Enamel reports. ANON. *Glashütte*, **66** [8] 135–37; [9] 167–70; [24] 408; [25] 421–22; [26] 451–52 (1936).—Abstracts of the latest researches in the field of enamels deal with (1) theoretical basis of enamel production, (2) raw materials and manufacture of enamels, (3) metallic base, (4) production and working, (5) enamel defects, and (6) operating contrivances. See *Ceram. Abs.*, **15** [3] 84 (1936). M.V.C.

Enamel spraying method. VIELHABER. *Emailwaren-Ind.*, **13** [24] 202–203 (1936).—The spraying of enamel is discussed with special emphasis on pressure, size of the nozzle, and methods of feeding the enamel into the spraying gun. M.V.C.

Enameling methods used abroad. W. O. *Emailwaren-Ind.*, **13** [24] 204 (1936).—American and French methods dealing with (1) color stability of enamel, (2) opacification, and (3) production of white ground enamel are briefly discussed. M.V.C.

Enameling without pickling. VIELHABER. *Emailwaren-Ind.*, **13** [32] 261–62 (1936).—The necessity of pickling raw ironware before enameling is discussed. M.V.C.

Enameling sanitary ware. H. J. KARMAUS. *Sprechsaal*, **68** [6] 83–86 (1935).—K. discusses the enameling of sanitary ware and the difficulties encountered. Several ground and coating enamels are analyzed. The powder and wet methods are described. M.V.C.

Enamels opacified white. ANON. *Glashütte*, **66** [3] 40–43; [4] 66 (1936).—The principles of opacification are discussed. Theoretically, various types of opacification are distinguished: (1) Constituents with higher refractive exponents in the enamel batch. This is the case which occurs most frequently and takes place when the opacifiers are added to the mill (tin oxide, antimonates, zircon compounds). (2) Opacification based on the separation of some materials in the enamel. This is obtained when fluorine compounds are melted in wet enamel; they dissolve at first and then separate during granulating of the melt or cooling of the ware. (3) Opacification based on phenomena of separation into component parts (calcium phosphate opacification). (4) Minute gas bubbles in the batch composed of the water of hydration of the clay added to the mill. Sometimes salts soluble in water, such as oxalates, hydrates, carbonates, organic salts, etc., are added to produce gas opacification. These main types of opacification are discussed in detail. M.V.C.

Firing enamel in the past and present. VIELHABER. *Emailwaren-Ind.*, **13** [28] 233–34 (1936).—Directions for firing enamel as given by Arno Erb (1836), later by P. Bull, and present methods used are described. M.V.C.

Gas opacifiers. L. STUCKERT. *Emailwaren-Ind.*, **13** [30] 249–52 (1936).—Details are given of experiments in the manufacture of enamels with gas opacifiers. The results are tabulated. The experiments showed that gas-opacified enamels comply with the requirements of technical enamels with regard to opacification, sensitivity to firing, and thermal and bending strengths. M.V.C.

Influence of furnace gases in enameling. KARL KAUTZ. *Metal Cleaning & Finishing*, **8** [6] 353–56 (1936).—Sources of furnace gases and the defects they cause in enameled ware are discussed. The percentage of oxygen content in the furnace atmosphere is given particular attention. E.J.V.

Measurement and significance of enamel thickness. H. H. HOLSCHER. *Jour. Amer. Ceram. Soc.*, **19** [10] 298–303 (1936).

Mechanical features of cleaning tanks. V. D. SMITH. *Enamelist*, **13** [6] 14–16 (1936).—The principal factors which assist the cleaning agent are proper methods of heat application and a suitable means of temperature control. The best place for installing the heating coil is on the working side of the tank, with the steam entering the bottom pipe first and discharging through the upper pipe. Installation of a valve or steam trap is advantageous in maintaining pressure in the coil. Excellent agitation of the solution can be obtained through the use of an agitation shield suspended over the heating coils. A heat-recording

device should be used to enable the most efficient cleaning temperature to be held. E.J.V.

Melting temperature and usability of enamel. L. VIELHABER. *Emailwaren-Ind.*, **13** [22] 188–89 (1936).—The effect of various melting temperatures of ground enamel and first and second white coats on the results of enameling are discussed. Ground enamel must generally melt at higher temperatures than coating enamels, but the firing temperature should not be exceeded as otherwise the enamel will not have sufficient time to react with the iron and a poor adherence will result. Coat enamel should melt more easily than ground enamel. Thermal expansion gives a good indication as to fusibility. M.V.C.

Methods and results of studies in enamel industry. W. O. *Emailwaren-Ind.*, **13** [22] 186–87 (1936).—(1) The production of acid-stable enamel with a high titanium content, (2) a special way of firing enamel, and (3) the use of a cobalt solution in enamel coats are discussed. M.V.C.

Novelty in the field of material testing and its importance in foundry practice. A. KARSTEN. *Giesserei*, **23** [11] 265–68 (1936).—Recent attempts to simplify and accelerate the taking of photomicrographs and to increase, by better illumination arrangement in the microscope, the accuracy and capacity of the instrument are reviewed; new photographic instruments are described. M.H.

Opacification. L. VIELHABER. *Emailwaren-Ind.*, **13** [20] 170–71 (1936).—The white coloring of enamel (opacification) depends to a great extent on the difference between the refractive index of the opacifier and that of the enamel. To obtain a strong opacification it is necessary to keep the refractive index of the enamel as low as possible. Alumina, magnesia, and lime increase it, while potassium, sodium, silica, and boric acid lower it. M.V.C.

Origin and prevention of defects in sheet-iron ground enamel. C. A. OTTERSBACH. *Glashütte*, **66** [23] 391–93; [24] 405–407 (1936).—One of the chief causes of the formation of fishscales is the effect of undesirable chemicophysical reactions of the separate constituents of the batch when fired; these formations later "explode," because of stresses in the enamel during firing of the ware, and form fishscales. The composition and working of ground enamel, especially firing, grinding, and the preparation of raw ware for enameling, are described in detail. Overfiring of enamel, cloudiness, copperheads, and seeds are dealt with. M.V.C.

Painting in porcelain enamel. G. W. PORTER. *Enamelist*, **13** [9] 34–35 (1936).—Enamels finely ground in oil can be used for painting. In preparing the enameled panels, a spray gun may be used to tone up the background. Wet enamels are rubbed on a roughened surface with the finger tips or brushed on like ordinary oil colors. If enamels are very finely ground, dried, and then mixed with refined liquid paraffin, they may be worked with the painting in an upright position and fired on while in the wet stage. Methods of making sketches are described. E.J.V.

Porcelain enamel clays. C. C. ENGLE. *Enamelist*, **13** [10] 10–12 (1936).—Work on domestic clays by frit manufacturers has resulted in clays or blends of domestic clays equal to Valendar clays in all respects and superior in some. A statement about origin and general composition of clays is given. A good enamel clay is of a type somewhere between a true ball clay and a true china clay. By combining ball clays having reasonable opacity and of fine-grained character with relatively fine-grained china clays or kaolins, an enamel clay having good physical and working properties should result. The function of particle size of enamel clays is very important and it is believed that 80% or more should be material under 7 microns, the remainder under 15 microns. E.J.V.

Powder enamel for signboards. HEINRICH KIRST. *Glashütte*, **66** [22] 377–79 (1936).—The composition and separate stages of production of powder enamel of various colors for signboards are discussed. M.V.C.

Porcelain steel tile for roofing. WILSON B. FISKE. *Enamelist*, **13** [8] 29–30 (1936).—Porcelain enameled steel roofing tile are made of strong enameling stock with all exposed edges turned in order to take enamel over the ends and sides, thus preventing possible rust at these susceptible points. These tile have been developed by Edwin A. Mastick, who has set up his own test roof to determine long-wearing qualities as well as for color research. Cost compares favorably with that of clay or cement tile while there are the advantages of longer wear, more attractive appearance, and greater ease in laying. E.J.V.

Practice in manufacturing enameled signboards. HEINRICH SASSE. *Emailwaren-Ind.*, **13** [21] 177–82; [22] 185–86 (1936).—S. discusses in detail all stages of the manufacture of enameled signboards, such as preparing the raw ware, enamels, compositions, firing, drying, and pigments. M.V.C.

Precautions taken to obtain a white enamel coat in one operation. HANS HADWIGER. *Glashütte*, **66** [9] 164–66 (1936).—H. reviews studies made in this field by various investigators, chiefly Americans. M.V.C.

Properties and manufacture of porcelain enameling sheets. H. E. ROMINE. *Enamelist*, **13** [7] 16–19 (1936).—Enameling sheets must be soft and ductile, so that they may be shaped easily by bending, stamping, or spinning operations. The drawing properties should be uniform throughout the sheet and there should be no conditions which would permit opening the surface of the sheet during drawing. Two methods of heat treatment of sheets are normalizing and box annealing. Cold reduced sheets when annealed possess a highly refined inner structure which gives them exceptional drawing qualities. Weldability, a dull surface often described as a velvet-like or mat finish, freedom from warping or buckling on firing, and good enamel adherence are other properties desired in enameling sheets. Laboratory tests can often determine the source of enameling defects. Illustrated. E.J.V.

Recent advances in quality of porcelain enamel cover coats. ANON. *Enamelist*, **13** [6] 17–18 (1936).—Comparing an enamel of eight years ago with a super-enamel now being produced shows the following advantages for the latter: (1) reduction in material required of at least two-thirds, (2) increased resistance to physical shock due to the thinness of application, (3) more even distribution of gas bubbles within the body of the enamel, (4) increased resistance to scratching, and (5) improved covering power. Illustrated with photomicrographs. E.J.V.

Recommended methods for testing and control of foundry molding sands. ANON. *Brit. Cast Iron Research Assn. Special Pub.*, No. 2, pp. 1–54 (April, 1934).—Methods and instruments for testing molding sands are re-

viewed; the advantage of carrying out both strength and permeability tests on one test piece in a standard double-compression core box is shown. The report deals with sampling, determination of moisture, mechanical properties, and chemical composition. A.P.S.

Relief enamels. L. VIELHABER. Translated in *Enamelist*, **13** [9] 24–25 (1936); see *Ceram. Abs.*, **15** [1] 11 (1936). E.J.V.

Resistance of enamel to wear. VIELHABER. *Emailwaren-Ind.*, **13** [26] 218–19 (1936).—The inadequacy of methods used to determine the resistance of enamel to wear is discussed. The method of Auerbach to determine the hardness of glass is dealt with. M.V.C.

Rolling up and cracking of enamel. L. VIELHABER. *Emailwaren-Ind.*, **13** [18] 153–55 (1936).—Sometimes the enamel coat breaks in several places because of strains; the edges bend, melt, and roll up. This may be due to a series of causes, such as a too finely ground enamel, lack of adherence, quality of the sheet iron used, and defective firing. An addition of borax to the ground enamel is recommended to improve adherence. M.V.C.

Sandblasting. W. G. MARTIN. *Enamelist*, **13** [9] 9–14 (1936).—The three systems of applying abrasive sand to the work, the induction system, the direct pressure method, and the newly developed centrifugal machine, are described individually. Since the sand cuts away the metal surface there are no films left on the surface. The roughness of the surface can be maintained to quite a satisfactory degree of uniformity. Roughness of the surface helps the pickup of ground coat in dipping and minimizes troubles, slipping, and secondary draining. E.J.V.

Sandblasting apparatus with centrifugal projection without compressed air. E. MONNOT. *Rev. Fonderie Moderne*, **30**, 211–14 (1936); see "Abrasive—" *Ceram. Abs.*, **15** [5] 139 (1936); "Sand—" *ibid.*, [8] 251. M.H.

Simple decoration methods. VIELHABER. *Emailwaren-Ind.*, **13** [25] 209–11 (1936).—A brief review is given of various methods used to decorate enameled ware. M.V.C.

Source of reboiling gases in porcelain enameled iron. KARL KAUTZ. *Enamelist*, **13** [6] 10–13 (1936).—A study of the problem of reboiling shows that it is not due to gases evolved from the enamel glass, entrapped air in cracks of the enamel, or occluded gases in commercial iron or steel. It is peculiar to commercial iron and steel only, requires the presence of an atmosphere containing oxygen during the initial firing, and does not occur on carbon-free iron or on pure electrolytic iron. All evidence points to the oxidation of the carbon in enameling iron and steel as the major source of reboiling gases. E.J.V.

Testing acid stability of enamel in practice. RICHARD ALDINGER. *Glashütte*, **66** [30] 508–12 (1936).—Methods used to test the resistance of enamels to chemical attack are discussed. The grit method is suitable for testing enamel granules as it determines the structure and quality of the enamel before further working. For testing fired enamel and finished ware, a simple method is recommended which shows the resistivity of enamel by observing the corrosive effect of a drop of the testing solution on the enamel. The results obtained are sufficiently exact in most cases, but this method can be developed into a quantitative method. For numerical comparisons of different enamels, the testing of ware by boiling with the testing solution is recommended. This method is especially important when determining whether the testing solution dissolves harmful materials out of the enamel. M.V.C.

Testing directions for enamelware. L. VIELHABER. *Emailwaren-Ind.*, **13** [18] 155 (1936).—V. reviews tests made to determine (1) color and luster, (2) uniformity of the enamel coat, (3) stability to temperature fluctuations, (4) impact strength, (5) resistance to chemical attack, and (6) safety of enamel. The necessity of developing adequate and standard tests is pointed out. M.V.C.

Use of a filter press in the pickle room. D. L. BENSINGER. *Enamelist*, **13** [10] 16–17 (1936).—Sources of insoluble materials in the neutralizer solution are (1) hard water, (2) iron salts carried over, forming insoluble salts, (3) dirt and other contamination, and (4) iron hydroxide from a nickel dip tank. The deposit of this insoluble material on the ware will cause trouble in the ground-coat dipping process, and after firing the ware may show a very uneven ground-coat application. B. suggests hooking up a filter press in connection with the neutralizer tank to remove the insoluble material, with a pump of such capacity as to effect a complete change of solution every two hours. E.J.V.

Welded stainless equipment. GEORGE H. TAY. *Ind. & Welding* [Second Quarter], pp. 68–69 (1936).—Cookers and storage and mixing equipment for foods are made of welded stainless steel with welds ground flush with the plate. A satin finish or polish is sufficient for most materials, but a high polish is necessary for corrosive materials. No welds are made in corners where the joint can not be ground because of the danger of contamination and fermentation from food lodged there. When properly welded and polished the joint is practically invisible. W.H.B.

Welding dairy equipment. J. HINDE. *Welder*, **8** [30] 941–42 (1936).—Stainless 18-8, Inconel, Sn-coating, Al, and glass lining are considered best for milk tank surfaces in contact. Fe, Sn, Ni, and Cr steels are not satisfactory. W.H.B.

Welding research at the Royal Naval College, Greenwich. ANON. *Welder*, **8** [30] 936–40, 953 (1936).—A review of reports on physical tests on load-carrying ability of welded joints of various types used in shipbuilding is given. Results of tests indicated little difference between single and double V welds and that the high tensile strength of welds is not necessarily associated with brittleness. Oxyacetylene welds give uniformly less satisfactory results and electric welds give properties closely approaching those of the plate. W.H.B.

Welding the Servel refrigerator. R. S. TAYLOR. *Ind. & Welding* [Second Quarter], pp. 42, 44 (1936).—Brief details are given. Both gas and arc welding are used. W.H.B.

Winning the battle against microbes. H. R. HANSON. *Ind. & Welding* [Second Quarter], pp. 45–47 (1936).—An illustrated account of the development of glass-lined equipment for processing and conveying food and food products is given. W.H.B.

Working methods and studies on cleaning sheet iron for enameling. M. SIEBERT. *Glashütte*, **66** [29] 495–98 (1936).—Calcining, sandblasting, chemical degreasing, and

acid pickling are discussed. The composition of degreasing and pickling baths is given. M.V.C.

BOOK

Bibliography of Non-Metallic Inclusions in Iron and Steel. Compiled by LOIS F. MCCOMBS AND MORRIS SCHRERO. Published by Metallurgical Advisory Board to Carnegie Inst. Tech., Pittsburgh. *Bull.* No. 70, 320 pp. Price $4.00. Reviewed in *Ind. Eng. Chem., News Ed.*, **13** [11] 251 (1935). F.G.H.

PATENTS

Composite article carrying a cellular backing of porcelain enamel and method of making. KARL TÜRK. U. S. 2,053,244, Sept. 1, 1936 (Dec. 28, 1935). A composite insulating article comprises a metal base having permanently united therewith a fused cellular insulating backing comprising the fusion product of a layer of vitreous enamel material in the presence of a gas-evolving agent, the thickness of the extended fusion layer being at least twice that of the original unfired layer of material, and the specific gravity of the insulating backing being at least one-half or less that of the specific gravity of the original vitreous enamel material.

Machines for cleaning and polishing metal sheets. R. THOMAS & CO., LTD., AND L. J. DAVIES. Brit. 451,127, Aug. 12, 1936 (April 12, 1935).

Glass

Acid polishing plants. RUDOLF HOHLBAUM. *Glashütte*, **66** [10] 183–87; [11] 203–206 (1936).—The composition of acid polishing solutions, which depends on the composition of the glass, is discussed, and directions for treating are given. A brief description of plants is included. Illustrated. M.V.C.

Amory Houghton, Jr. G. B. HOLLISTER. *Bull. Amer. Ceram. Soc.*, **15** [9] 322 (1936).

Building modern display windows. M. GERSTL AND EMIL WEISS. *Tchéco Verre*, **3** [3–4] 72–75 (1936).—The functions of glass and the display window are described. 10 illustrations. R.B.

Coloration of glasses by copper, selenium, and sulfur: I. H. WECKERLE. *Glastech. Ber.*, **11** [8] 273–85 (1933).—(*A*) *Copper reds.* The theory of the color of copper ruby glass and the actual methods used in the preparation of the ruby glass are discussed. The influence of copper and the concentration of reduction materials on the color is treated. The equilibrium between oxidized copper and metallic copper is estimated. Grain size was determined by ultramicroscopic methods. (*B*) *Selenium glass.* In addition to discussions of the theory of color formation and the influence of oxidizing and reducing materials on the color, the composition of selenium vapors with additions to the melt of oxidizing and reducing substances is treated. Attention is given to the relation of the vapor of selenium to the melting temperature and to the gaseous content of the melt. **II.** *Ibid.*, [9] 314–23.—(*C*) *Selenium cadmium sulfide ruby glasses.* Variation of composition of a technical selenium ruby glass for the preparation of the necessary color is given. Other topics discussed are the rôle of the necessary constituents for color, glasses colored by sulfur and carbon, theory and practice of coloring with sulfur, and the relationship of color to colored constituents. The relation between the amounts of sulfide sulfur remaining in the glass and the amount added by the introduction of sulfur through Na_2SO_4 and carbon is also dealt with. G.R.S.

Conveying platforms for annealing furnaces. FOURMENT. *Verre & Silicates Ind.*, **7** [6] 65–67 (1936).—The conveying platform of Fourment and Ladurée consists of two sets of steel bars which rest on small eccentric supports on transverse shafts distributed regularly along the chamber. One set of bars rises and advances while the alternate bars descend and recede. The platform can be divided into a certain number of longitudinal sections, each with its own particular speed (regulated as desired). Heavy and light objects can be annealed simultaneously. Further particulars are given. M.V.C.

Dependence of various properties of glass, especially that of becoming rough when treated over a burner, on chemical composition. F. H. ZSCHACKE. *Sprechsaal*, **69** [22] 310–13 (1936).—On the basis of a series of experiments with glass tubes, the working properties of the glass when treated over a burner were studied, and the dependence of these properties on the chemical composition of the glass is dealt with. The melting properties and working of this glass are discussed. M.V.C.

Determining boric acid in glasses. ZSCHACKE. *Glashütte*, **66** [30] 507–508 (1936).—The determination of boric acid according to the method of Glaze and Finn (*Ceram. Abs.*, **15** [8] 234 (1936)) is studied. M.V.C.

Effect of chemical after-treatment on the resistance of glass bottles to inner pressure. K. H. BORCHARD AND F. H. ZSCHACKE. *Glashütte*, **66** [32] 535–38 (1936).—Experiments showed that the resistance of glass bottles to inner pressure may be influenced by treating the outer surfaces of bottles with a hydrofluoric and sulfuric acid mixture. The resistance to pressure is at first lowered, then later increases considerably with a longer duration of the treatment. The same phenomena were registered in other experiments. With a still longer treatment, the strength decreases again, owing to the fact that hydrofluoric acid attacks the invisible fissures present and enlarges them. Further effect of the hydrofluoric acid consists in smoothing off these scratches and the strength increases. By this time, however, the fissures deepen and increase from the effect of the acid and the strength declines again. M.V.C.

Effect of heat treatment on the physical properties of glass. J. T. LITTLETON. *Bull. Amer. Ceram. Soc.*, **15** [9] 306–11 (1936).

Electric kilns with central resistance heating. V. ŠKOLA. *Slavivo*, p. 386 (1935).—Such a kiln is used for melting quartz glass by the Quarz et Silice Co. at Chauny et Cirey. In the 270-kw. kiln a temperature of 2000°C is reached and ingots from smelted quartz, 25 cm. x 1 m., weighing about 20 kg., are made within $6^1/_2$ min. after the raw material has been placed in the cool kiln. Even a temperature of 2700°C may be reached, *e.g.*, in melting MgO. R.B.

Electrically heated furnaces in the glass industry and

their efficiency: III, Annealing furnaces. J. HOROWITZ. *Glashütte*, **66** [26] 444–47; [27] 463–64 (1936).—A detailed discussion of the effect of operating factors on the output of electric annealing furnaces is given. Formulas for calculations are developed. Illustrated. For Part II see *Ceram. Abs.*, **15** [1] 13 (1936). M.V.C.

Electrically heated glass furnaces: I, Story of their development. H. NATHUSIUS. *Glastech. Ber.*, **12** [11] 385–87 (1934).—A brief discussion is given of three types of electrical heating: (1) heating with the electric arc, (2) indirect resistor heating, and (3) direct resistor heating. Patents, dating from 1899 to 1931, for electroglassmelting are described and illustrated. **II, Construction and results of operation of the electric glass furnace of Brown, Boverie, and Co.** *Ibid.*, pp. 387–88.—The first electric research furnace for melting glass was built in 1932. Globar rods were used for heating elements. Less time was required for fusing the batch and fining the glass than with a gas-fired furnace for the same glass batch. From operation of the furnaces the following data were obtained. In the afternoon the furnace was charged with batch and cullet which was fused during the night. The finished melt was worked on the following day. Melting required about 9 to 10 hr., fining 4 to 5 hr., and standing 3 to 4 hr. The current required for melting was about 400 kw.-hr., for fining 200, for standing 75, and for working 225, totaling 900 kw.-hr. With a yield of 400 kg. of glass the current for melting (without working out) was 2.25 kw.-hr./kg. of glass. **III, Description of an electric glassmelting furnace of the Siemens-Schuckert Works.** ANON. *Ibid.*, pp. 388–89 (1934).—For fusing 35 kg. of glass, the furnace dimensions were 348 mm. in diameter and 400 mm. in height, while the outside diameter was 1026 mm. and the height 1125 mm. The highest temperature attained was 1300°C, which was entirely sufficient for melting the glass. Owing to better uniformity of temperature in the electric furnace, lower temperatures than in a gas-heated furnace were employed. The glass was free from contamination by flue gas and ash or slag from fuel. The furnace was regulated automatically by means of a Pt-Pt Rh thermocouple connected to a thermoregulator. The life of the heating unit was good and the furnace economical. **IV, Bibliography of the literature on electrical glassmelting.** R. SCHULTZE. *Ibid.*, p. 389.—Twenty-seven books and publications are listed. G.R.S.

Flowing processes in the automatic manufacture of bottles by the feeder process with the Owens Bottle Company machine. W. EITEL. *Glastech. Ber.*, **12** [7] 222–27 (1934).—All the structure forms of melts, bulbs, and bottles are the peculiarities of the feeder processes provided by glass flowing through rotating refiners and shear cutters which are accompanied by a symmetrical arrangement of material and physical inhomogeneities. The process of structure development is entirely a path of force and, in general, can not be altered with a given mechanical device. This fact is a new confirmation of similar observations on the Lynch feeder method and the Owens suction process. See *Ceram. Abs.*, **12** [1] 13 (1933). G.R.S.

Fused silica globes for lighting. EDITORIAL. *Indian Eng.*, **99** [3] 108 (1936).—The Thermal Syndicate, Ltd., the pioneer firm in the field of fused silica ware, commenced detailed research work in 1903 and finally evolved a patent process of melting silica at about 1700 to 1800°C consisting in passing a powerful electric current through carbon rods lying in the raw material. This may be rock crystal, geyserite, or certain varieties of sand which, with the exact methods of operation, largely determines whether the product is transparent, translucent, or opaque. In all cases, however, the ware is 99.8% SiO_2 or more and has the same properties, the degree of transparency being determined by the presence of minute bubbles of entangled air or gas. The properties of Vitreosil fused silica ware include, apart from high resistance to heat (up to about 1100°C), high transparency to ultra-violet ray, high electrical insulation, resistance to every known acid or mixture of acid, hot or cold, except hydrofluoric and phosphoric, and entire absence of expansion. The actual coefficient within the range of 0 to 1000°C is 0.00000054/1°C so that no ill effect results when any object made of Vitreosil fused silica is heated white hot and plunged into cold water. This rate of expansion is the lowest of any known substance, being about $^1/_{17}$ that of ordinary glass, $^1/_{10}$ that of hard Jena glass, and $^1/_2$ that of the special nickel steel, Invar metal. Consequently, fused silica is ideal for electric and gas lighting globes, pyrometer sheaths, electrical heating equipment, high-powered wireless valves, and mercury vapor lamps. A.P.S.

Glass building brick in Australia. ANON. *Chem. Eng. Mining Rev.*, **28**, 362 (July, 1936).—The Australian Glass Mfrs. Co. has commenced production in Sydney of glass brick, solid and hollow, with the object of making possible better lighting conditions. The brick are sound-insulating, fire-resistant, moisture-proof, and of great structural strength. H.H.S.

Glass in modern building activity. JAR. POLÍVKA. *Vestnik Spolku Ceskoslov. inzenyru*, p. 31 (1936).—Glass has still other functions in modern building activity besides lighting and ventilating. Special efforts are being made to diminish the amount of heat which the glass allows to pass through, to increase sound insulation, to decrease direct sunlight glare, to obtain a perfect diffusion of light and an even lighting of the room, and to utilize glass for supporting weight. Modern glass plates consist of two thin plates with a layer of fine glass tissue, 1 to 3 mm. in thickness, between them. This causes a heat insulation as effective as if the two plates were insulated by a layer of air 15 cm. thick; it prevents the condensation of water-vapor, the so-called sweating of windows, and increases the insulation of sound. It is also more effective in the diffusion of light. R.B.

Glass silk. ANON. *Chem. & Ind.*, **53** [49] 1041–42 (1934).—Glass silk is made by a process in which the original good quality glass is "spun" to fine strands possessing high tensile strength and is, therefore, capable of being folded and crushed without ill effect. Since it is non-hygroscopic it prevents corrosion of insulated surfaces. It is also insect, fungus, and rodent proof. All its properties contribute to an exceptional degree of permanence and economy. G.R.S.

Glass silvering. H. SCHULZ. *Glashütte*, **66** [25] 419–21 (1936).—After a historical review of the process of silvering, details of procedure are given as to the formalin, Seignette salt, tartaric acid, and Brashear methods. M.V.C.

Glass yarn as insulating and filtering media. RUDOLF LEHMAN AND EBERHARD ULLRICH. *Glashütte*, **66** [22] 375–77; [23] 393–95; [24] 403–405 (1936).—Spinning drums and automatic spinning machines are usually used for the production of glass wool. The wool is manufactured from glass rods which are heated and from which glass threads are drawn. Lately, however, the liquid glass is conveyed to the spinning machines in the form of threads. At present a German glass plant manufactures a very fine glass wool for textiles; the glass is worked directly out of the furnace. The two great fields of application are insulation and filtration. It is shown that this glass wool is much superior to foreign insulating and filtering media. M.V.C.

Homogeneity of glass. J. HRDLIČKA. *Sklarske Rozhledy*, **13** [1] 3–7 (1936).—Testing is done by means of the projecting method. The lack of homogeneity and the tension, which can not be removed through cooling, show a similarity which leads to the supposition that a qualitative relation exists between the two properties. However, some glass did not show this relation. R.B.

Improved hollow glassware. W. VON EIFF. *Glashütte*, **66** [8] 123–26 (1936).—Ways of obtaining artistic hollow glassware in ancient times and at present are discussed. Illustrated. M.V.C.

Improving glass. HANS SCHULZ. *Glashütte*, **66** [8] 129–30 (1936).—Methods used to improve the appearance of glassware are discussed. M.V.C.

Influence of previous thermal treatment of glass on its chemical composition and working properties as well as on its physical and chemical properties. L. SPRINGER. *Keram. Rundschau*, **43** [51] 601–604 (1935).—A glass of defined chemical (elementary) composition may have, according to temperature and duration of melting or cooling, a different inner structure and different working properties. The previous thermal treatment explains why pot or tank glass differs and why glasses from different origins are unlike. Cullet needs an addition of flux. Viscosity in the vicinity of 1200°C is irregular, probably because of two modifications of the glass. It is impossible to produce at will one of these modifications. Turner has verified that glass containing more than 40% cullet is stiffer and shorter, provided that the batch is very damp and the limestone very coarse. A small addition of salt cake, soda, or borax gives back the usual properties. Glasses melted 20 times in platinum crucibles have shown a lack of homogeneity which is responsible for brittleness and change of workability. An ordinary pot glass left during one month at high temperature by Gehlhoff lost in alkali and lime and gained in alumina and iron. A lead glass, after two months, lost $5^1/_2$% lead oxide and gained enormously in silica, alumina, and iron; the alkali remained unchanged. A lime-magnesia glass melted 20 times showed only an increase of alumina; its viscosity curve was 30°C higher than before. In a borax glass, the same phenomenon was more noticeable due to the volatility of boron. These tests speak against the influence of previous thermal treatment. Quickly cooled glass is less resistant to chemical attacks. Chemical cooling effect is due not only to SO_2 but also to CO_2 and H_2O. This is particularly important for drawn sheet glass. Fourcault glass exposed to the action of these gases for 3 hr. at 420°C increased its surface resistance by 50%. It is possible to increase the quality of inner surfaces of hollow ware with ammonium salts and volatile acids in the containers; the required temperature is usually 400° to 600°C. S. gives a short outline of changes of physical properties due to cooling. F.E.V.

Isochromats in glass with strains. JAR. POLÍVKA, L. FÖPPLA, AND H. NEUBERA. *Tchéco Verre*, **3** [3–4] 91–94 (1936).—The damaging of glass is generally dependent not only on the difference in the main tensions but, in accordance with Mokr's theory, also on the sum of these tensions. Thus, it is impossible to define the permissible strain in a particular kind of glass if, at the same time, the total of the main tensions is not stated. By means of an analogy, 40 isochromatic circles may be ascertained in Bakelite. R.B.

Knowledge and advice given at St. Gobain in the 18th Century. W. GANZENMÜLLER. *Glashütte*, **66** [15] 267–69 (1936).—The life of Paul Bosc d'Antic, born in 1726 and connected with the famous St. Gobain glassworks, is briefly discussed. M.V.C.

Laboratory test method for automobile lights. P. CIBIE. *Compt. Rend.*, **202** [26] 2136–38 (1936).—A method of testing automobile lights is described which can be made on a screen only 1 m. distant from the light of about 20 cm. diameter with the aid of a convergent optical system between light and screen. M.H.

Melting glass in the by-product gas producer with simultaneous production of metallic iron. JULIUS LAMORT. *Glastech. Ber.*, **14** [2] 54–60 (1936).—In the by-product gas producer, glass from volcanic rock can be melted by the use of a preheated air blast, whereby the iron content of the charge, which is very high in basalt, is obtained as metal. The following points in this process were studied: (1) the use of phonolite and granite instead of basalt, manner of introduction of alkalis, and the question of loss of alkalis by volatilization; and (2) output of the furnace, *i.e.*, gas production, glass melted, and iron delivery. G.R.S.

Melting speed. ANON. *Glashütte*, **66** [19] 331–32 (1936).—The speed and time used for melting various glass batches is discussed. Experiments are briefly described. M.V.C.

Old families of master glass-smelters. JAN BÁRTA. *Sklarske Rozhledy*, **13** [3] 33–35 (1936). R.B.

Origin, testing, and prevention of drops in tank glass. JULIUS LAMORT. *Sprechsaal*, **69** [18] 250–51 (1936).—A ring-like corrosion of tank brick takes place in tanks at the surface of the glass. With a sufficient depth of corrosion, difficultly fusible and very viscous silicates originate from the effect of the batch dust in the overhanging brick and drop into the melt. This phenomenon is especially noticeable in brick with a high alumina content (> 20%), while those with a lower alumina content melt more uniformly. Tapering the highest brick layer to below the glass surface is of some help. Drops are also sometimes formed under the surface of the glass through corrosion. M.V.C.

Protection of walls in tank furnaces. OSKAR ARENDT. *Glashütte*, **66** [15] 269–70 (1936).—The use of cylindrical bodies floating on the surface of the molten glass and protecting the walls of the tanks from destruction is described. Illustrated. M.V.C.

Radioactivity of glasses. ADOLF TROST. *Z. Physik*, **100** [9] 549–52 (1936).—T. found that certain types of glasses are radioactive. He concluded that the activity is due to small amounts of impurities in the glasses which are not detected by the ordinary chemical analysis. The amount of radiation for the various glasses was measured. L.T.B.

Raman effect and structure of glasses. TH. G. KUJUMZELIS. *Z. Physik*, **100** [3] 221–36 (1936).—The Raman spectra were obtained for various types of glasses (with and without silica), crystalline and amorphous quartz, and boric anhydride glass. The Raman spectra change systematically as a function of the SiO_2:PbO ratio. The following interpretation is given to the data: Glass consists primarily of oxygen ions which are coördinately rather than chemically bound to each other and to the glass-forming elements (boron, silicon, etc.). The Raman effect is caused by the inner vibrations of definite complex groups; the vibrations are influenced by the number and type of atoms in the group. These groups may have all orientations and therefore give no sharp X-ray patterns. L.T.B.

Raman spectra of glasses: I. TH. G. KUJUMZELIS. *Z. Physik*, **97** [9] 561–69 (1935).—The Raman spectra of some glasses made by Schott and Co., Jena, were obtained. For each type of glass a characteristic spectrum is obtained. The spectra obtained do not correspond to the Raman spectra of crystalline quartz. L.T.B.

Results of using unsuitable glass pots. ANON. *Glashütte*, **66** [13] 235–36; [14] 253–55; [15] 270–72 (1936).—A case in a large hollow glassware plant where the use of unsuitable glass pots led to great difficulties in the manufacture of glassware is described. Illustrated. M.V.C.

Rock wool. M. F. GOUDGE. *Can. Mining Met. Bull.*, No. 293, pp. 623–34 (1936).—Rock wool is made in three Canadian plants. G. discusses raw materials, methods of manufacture, and uses. No special health hazards affect workers in this industry. See *Ceram. Abs.*, **13** [8] 226 (1934); **14** [10] 263 (1935). G.M.H.

Safety glass. F. H. ZSCHACKE. *Keram. Rundschau*, **43** [43] 505–507 (1935).—A historical outline of development is given. The process of manufacture of safety glass, including Securit hard glass, is briefly described. The usual tests are indicated. 6 illustrations. F.E.V.

Schott's earlier works and their significance for the glass technologist. G. KEPPELER. *Glastech. Ber.*, **14** [2] 49–54 (1936).—The manner of life and course of studies of Otto Schott, his work in laboratory and plant, and his earlier publications are described. The presentation concludes with the time when he joined with Abbé. See *Ceram. Abs.*, **15** [10] 298 (1936). G.R.S.

Shatterproof glass now bonded with acetate. ANON. *Brit. Plastics*, **5** [60] 544 (1934).—Fibertos, a cellulose-acetate product, is replacing pyroxylin plastics in shatterproof glass manufacture because of its freedom from smudge, haze, and other imperfections, and from discoloration encountered with cellulose nitrate. Since a lower amount of scrap is trimmed off, the cost of laminating with acetate is little or no more than with nitrate and a superior and more enduring product is secured. The decreased fire hazard involved in storage and safe handling of the product and scrap give acetate sheets an advantage over nitrate. G.R.S.

Silica as a raw material for glass. G. AND TH. *Glashütte*, **66** [27] 464–67 (1936).—The significance of silica in the formation of glass and its properties, occurrence, deposits, and treatment are discussed in detail. M.V.C.

State-authorized experimental and testing institute for glass industry at Hradec Králové, Czechoslovakia. ANON. *Tchéco Verre*, **3** [3–4] 66–67 (1936).—A description of the equipment of the institute is given. 5 illustrations. See also "Glass research—" *Ceram. Abs.*, **15** [10] 297 (1936). R.B.

Thermal flow in tanks on the basis of tests with models. A. SCHILD. *Glastech. Ber.*, **11** [9] 304–14 (1933).—An outline of the purpose of the test model and its use in combination with plant observations is given. Basic resemblances of the research model to plant studies are pointed out. The discussion includes thermic stream paths in the central zone of a tank, thermic transverse streams, and their influence on the total stream formation. Results on the influence of the streaming on a special type of furnace construction are given. Illustrated with diagrams and photographs of the model and tanks in actual use in glass plants. G.R.S.

Variability of chemical properties of glass. GUSTAV KEPPELER. *Glastech. Ber.*, **12** [11] 366–72 (1934).—A rough support is given for estimating the change in ease of attack by molecular replacement of the glass oxides by a comparison of their water solubilities. A more exact determination is obtained only by investigation of the complete glass system. With a given glass composition, the ease of attack of formed surfaces is strongly dependent on the manner of their formation (free blown, drawn, molded, pressed, etc.) and their after-treatment (the action of heat, chemical action of cooling gases, grinding and polishing, etc.). As a result, the ratios of the values for powder and original surface extraction fluctuate widely. For better clarity the dependence of extraction on time was gone over and it was found that this dependence is represented very closely by parabolas. The comparison of the course of the extraction with the course theoretically calculated from the behavior of the deeper layers gives a clearer insight into the variation of the different surfaces treated. Acid gases produce the strongest compensation at suitable temperatures. Heating without the action of cooling gases makes the surface richer in alkali. The influence of grinding and polishing is to improve stability but not to the extent of the treatment with acid vapors. 21 references. G.R.S.

Velocity of surface attack on acid-soluble glasses and its dependence on thermal history. E. BERGER. *Glastech. Ber.*, **12** [6] 189–98 (1934).—A description is given of the method of measuring the speed of surface attack. The formation of flakes occurs in general as a paraboloid. The weakening of an overlying surface layer may be explained by the enlargement of deep cracks. Changes of composition, temperature, and constitution exhibit themselves strongly by increasing the speed of surface attack. The greater ease of attack of quenched glass is made clear, on the basis of the explanation of Zachariasen, by the decrease of the binding power of the atoms, followed by an increase of their stability to oxygen atoms, which produces a change of the coördination number. G.R.S.

What glass raw materials should be controlled? LUDWIG SPRINGER. *Glashütte*, **66** [31] 523–26 (1936).—The

chief raw materials used for glassmelting are discussed with regard to their composition, secondary ingredients, and harmful ingredients: (1) Soda used in glassmelting is more or less standardized; it contains from 0.002 to 0.003% iron oxide, 1% common salt, and very little Glauber salt. The moisture content and granulation are important. Potash absorbs moisture easily; hydrated potash contains 17% water. Potash from beet molasses (a by-product of sugar production) melts better. (2) Pure limestone contains over 98% carbonate of lime, sand, clay, and 0.1% Fe_2O_3; ordinary limestone has 90 to 95% carbonate of lime, sand, clay, some magnesia, and up to 0.3% Fe_2O_3; lime marl and clay marl contain the same impurities but of a higher content, especially clay; dolomitic limestone and dolomite are limestones with more than 5% magnesium carbonate. With regard to the grain size or grinding fineness of limestone, there are no definite data. (3) Minium can be considered to be lead oxide with surplus O; 100 kg. minium yields 97.7 kg. PbO and 2.3 kg. O in glass. Various kinds of lead are found on the market. High-grade minium should contain at least 30% lead superoxide. A higher content than 0.2 to 0.5% metallic lead attacks the glass pots. Minium also contains opacifying impurities, such as antimony and tin, pigments, manganous and copper oxide, and traces of nickel and cobalt oxide. (4) The moisture content, grain size, and carbon content of sand are discussed. The determination of iron and carbon present in sand is dealt with. M.V.C.

BOOKS

Directory of the Glass Industry, 1936 (Adressbuch der Glas-Industrie). ANON. Published by *Sprechsaal*, Müller and Schmidt, Coburg, 1936. 996 pp. Price 15.50 Rm. The directory contains addresses of glassworks, kinds of glass manufactured, and related industries of the world classified according to countries. M.V.C.

Manufacture of Mirrors (Die Spiegelfabrikation). LUDWIG WINKLER AND RICHARD ERNST. A. Hartlebens Verlag, Vienna and Leipzig, 1936. Vol. 402 of the Chemicotechnical Library. 137 pp., 38 illustrations. Price 5 Rm. Reviewed in *Sprechsaal*, **69** [24] 352 (1936).—A short description of the history of mirror manufacture and production of plate glass precedes the main part of the work which deals with mirror coating: (1) materials used for coating, (2) coating with silver, (3) tin-mercury amalgam, (4) gold, (5) platinum, (6) copper, etc. M.V.C.

PATENTS

Apparatus for:

Casting large glass articles. CORNING GLASS WORKS. Brit. 451,328, Aug. 19, 1936 (Feb. 28, 1935).

Continuous manufacture of sheet glass. LOUIS BOUDIN (Soc. Anon. des Manufactures des Glaces & Produits Chimiques de St. Gobain, Chauny & Cirey). U. S. 2,052,212, Aug. 25, 1936 (Nov. 11, 1932).

Cutting glass. JOSEPH GASKELL (Pilkington Brothers, Ltd.). U. S. 2,051,698, Aug. 18, 1936 (Jan. 8, 1935).

Drawing thermometer tubing. W. J. WOODS (Corning Glass Works). U. S. 2,052,269, Aug. 25, 1936 (July 5, 1934).

Manufacture of laminated glass. F. L. BISHOP, C. S. SHOEMAKER, L. J. PIERCE, C. F. WOOD, AND EDLO DONNINI (American Window Glass Co.). U. S. 2,052,545, Sept. 1, 1936 (May 6, 1933).

Producing glass strip. PILKINGTON BROS., LTD., AND F. B. WALDRON. Brit. 452,381, Sept. 2, 1936 (Feb. 20, 1935).

Decorated glass and method of manufacturing it. H. PERRY AND A. W. GROTEFELD. Brit. 451,035, Aug. 12, 1936 (Jan. 28, 1935).

Furnaces for heating glass plates for tempering. PILKINGTON BROS., LTD., AND L. J.-B. FORBES. Brit. 452,443, Sept. 2, 1936 (Feb. 21, 1935).

Gage glass. L. I. DANA (Union Carbide and Carbon Corp.). U. S. 2,053,765, Sept. 8, 1936 (Jan. 26, 1933).

Glass articles and method of making. A. H. STEWART. U. S. 2,053,923, Sept. 8, 1936 (March 2, 1935). A shaped glass article has a portion of its surface coated with metal sprayed thereon while the article is still hot from the shaping thereof.

Glass coffee maker. H. F. UMSTOTT (Westinghouse Electric & Mfg. Co.). U. S. 2,053,451, Sept. 8, 1936 (Sept. 23, 1933).

Glass feeder and method. W. L. MCNAMARA (Capstan Glass Co.). U. S. 2,052,578, Sept. 1, 1936 (Oct. 24, 1931).

Glass feeding apparatus. G. R. HAUB (Shawkee Mfg. Co.). U. S. 2,053,663, Sept. 8, 1936 (Feb. 25, 1932).

Glass feeding method and apparatus. A. H. STEWART (Ball Brothers Co.). U. S. 2,053,381, Sept. 8, 1936 (Nov. 23, 1934).

Glass-grinding apparatus. PILKINGTON BROS., LTD., AND J. H. GRIFFIN. Brit. 450,605, Aug. 6, 1936 (Jan. 21, 1935). PILKINGTON BROS., LTD., AND F. B. WALDRON. Brit. 452,380, Sept. 2, 1936 (Feb. 20, 1935).

Glass level indicator. W. T. BARKER, JR. (Hartford-Empire Co.). U. S. 2,053,938, Sept. 8, 1936 (Jan. 7, 1932).

Glass pressing machine. A. H. LE MARE (Pilkington Brothers, Ltd.). U. S. 2,053,402, Sept. 8, 1936 (April 28, 1934).

Glass snapping machine. EDWARD OSTERMIER (Pittsburgh Plate Glass Co.). U. S. 2,052,243, Aug. 25, 1936 (June 23, 1933).

Glass for telegraph insulators, etc. GENERAL ELECTRIC CO., LTD., AND J. H. PARTRIDGE. Brit. 451,308, Aug. 19, 1936 (July 5, 1935).

Glassware forming machine. C. C. COOK AND CHARLES BADGER (Owens-Illinois Glass Co.). U. S. 2,051,468, Aug. 18, 1936 (June 14, 1933; renewed Jan. 22, 1936).

Glassworking apparatus. H. R. SCHUTZ (Libbey Glass Co.). U. S. 2,050,386, Aug. 11, 1936 (March 9, 1935).

Improved glass tempering method. W. W. SHAVER (Corning Glass Works). U. S. 2,052,254, Aug. 25, 1936 (Dec. 26, 1934). A process of tempering glass sheets and other glass articles consists in heating the glass to a temperature at which it commences to soften, thereupon immersing the glass into a liquid bath of lower temperature, and imparting a vigorous agitation to the liquid bath at the moment the glass is immersed and during the whole time it is held in the bath.

Joining or cementing glass building units. J. F. HYDE (Corning Glass Works). U. S. 2,052,229, Aug. 25, 1936 (May 21, 1934).

Lens. J. D. CHALFANT. U. S. 2,051,327, Aug. 18, 1936 (June 13, 1934). An antiglare lens comprises a plurality of

superposed rows of vertically extending individual surfaces, each of which is disposed generally in a plane different from the general plane of the lens.

Lens grinding machine. J. A. Cook (Jay W. Stack). U. S. 2,051,329, Aug. 18, 1936 (Sept. 3, 1935).

Machine for the manufacture of glass bottles. W. B. Mitchell. Brit. 451,343, Aug. 19, 1936 (Nov. 30, 1934).

Manufacture of:

Articles of glass in combination with plastic materials. Pilkington Bros., Ltd., and L. J.-B. Forbes. Brit. 451,507, Aug. 19, 1936 (Feb. 6, 1935).

Bottles or like containers. C. Nicolle. Brit. 452,245, Sept. 2, 1936 (Nov. 21, 1935).

Cyanhydrins. Triplex Safety Glass Co., Ltd., and J. Wilson. Brit. 452,285, Sept. 2, 1936 (Jan. 19, 1935).

Laminated glass. R. H. Du Bois (American Window Glass Co.), U. S. 2,052,286, Aug. 25, 1936 (April 26, 1933). E. P. Fisher (American Window Glass Co.), U. S. 2,050,300, Aug. 11, 1936 (May 6, 1933).

Laminated safety glass. K. S. Low. Brit. 451,247, Aug. 12, 1936 (Feb. 6, 1935).

Stratified bodies such as safety glass. Triplex Safety Glass Co., Ltd., and J. Wilson. Brit. 451,872, Aug. 26, 1936 (April 9, 1935).

Method of and apparatus for melting glass. S. A. Forter (H. L. Dixon Co.). U. S. 2,053,902, Sept. 8, 1936 (April 21, 1932).

Method of tempering a glass article. Corning Glass Works. Brit. 452,268, Sept. 2, 1936 (April 17, 1935).

Mineral wool. J. T. Thorndyke (Alfred W. Knight). U. S. 2,051,279, Aug. 18, 1936 (March 21, 1934). A mineral wool is prepared by fusing a high calcium mineral selected from the pyroxene mineralogical group and having a composition represented by the general formula $RSiO_3$ in which the molecular proportion of silica is substantially equal to the molecular proportion of the other metal oxide or oxides present in the mineral, and blowing a stream of such molten mineral to form fibrous strands.

Molten glass shears. W. H. McSwain (Moses Cohen). U. S. 2,053,039, Sept. 1, 1936 (Jan. 25, 1935).

Multifocal lens and method of making. G. A. Clement. U. S. 20,059, Aug. 11, 1936 (Nov. 17, 1933); reissue of original U. S. 1,911,806, May 30, 1933. Edward Culver and S. A. Emerson (United Kingdom Optical Co., Ltd.). U. S. 2,053,551, Sept. 8, 1936 (July 9, 1934).

One-piece multifocal lens. A. D. Hurst and F. E. Duckwall (Continental Optical Mfg. Co.). U. S. 2,050,755, Aug. 11, 1936 (April 30, 1934).

Ophthalmic lens. H. R. Moulton (American Optical Co.). U. S. 2,050,540, Aug. 11, 1936 (Oct. 28, 1933). The process of changing a glass surface so that it will have a different reaction to vapor than it ordinarily has comprises applying thereto a solution of hydrofluosilicic acid and stannous chloride to form a visible coating and subsequently removing the visible coating without changing the reaction qualities of the glass.

Process of making fused silica and silica glass. Corning Glass Works. Brit. 450,927, Aug. 6, 1936 (July 18, 1935).

Process for the preparation of silica for glass batches. H. P. Hood (Corning Glass Works). U. S. 2,052,227, Aug. 25, 1936 (June 27, 1934). The method of preparing silica for use in glass batches includes introducing the silica into an acid solution, adding thereto a flotation oil comprising a sulfur derivative of cresol, agitating the solution in a flotation apparatus to float off the iron impurities, and drying the silica.

Receptacles for containing glass during manufacture. General Electric Co., Ltd., and J. H. Partridge. Brit. 450,583, Aug. 6, 1936 (May 15, 1935).

Shield for glass tank feeding shelves. G. W. Batchell (Owens-Illinois Glass Co.). U. S. 2,051,238, Aug. 18, 1936 (March 22, 1929).

Structural Clay Products

Brick manufacture in Russia. L. Segal. *U.S.S.R. Handbook*, **1**, 210 (1936).—Production of all types of brick in Soviet Russia totalled 4928 million in 1932 and 3650 million in 1934. H.H.S.

Buildings made of brick masonry in Czechoslovakia. R. Barta. *Stavivo*, p. 26 (1936).—The oldest brick building in Czechoslovakia is the Prague Synagogue, the foundation of which dates from the 6th Century. The use of masonry was not revived until the 19th Century, and today there are a great many modern representative buildings, homes, and villas made of this material. 11 illustrations. R.B.

Cause of brittleness in de-aired heavy clayware. H. R. Straight. *Bull. Amer. Ceram. Soc.*, **15** [9] 323–24 (1936).

Choice of pipe material for sewers: V. Hugo Bronneck. *Clay Prod. Jour. Australia*, **3** [9] 19–21 (1936).—B. discusses whether it is possible to protect concrete pipes against corrosion. He negatives the idea that the deposition of fine colloidal parts of refuse can form a protective "sewer skin" in the pipe. The use of concrete is condemned wherever corrosive substances can enter the drainage, the underground water, or the soil. **VI.** *Ibid.*, [10] 11–14.—B. discusses the proved weaknesses of spun concrete and of asbestos cement pipes. For Part **IV** see *Ceram. Abs.*, **15** [9] 275 (1936). H.H.S.

Europe's experience with sewer pipe. Editorial. *Clay Prod. Jour. Australia*, **3** [9] 1–2 (1936).—Australia is about to spend large sums of money on sewerage schemes. The claims of the two main classes of pipe, stoneware and concrete, are being considered by engineers and municipal councils throughout the country. The experience of Europe is recounted as argument in favor of stoneware. Out of 20 west German towns, 15 were obliged to rebuild their pipe lines, changing from concrete to stoneware. H.H.S.

Hollow wall is coming back. Anon. *Brick Clay Rec.*, **88** [6] 236–38 (1936).—The publicity of air conditioning and insulation is reviving interest in the cavity wall. The cavity wall eliminates moisture penetration, permits the use of insulation, can be designed to be cheaper than a solid masonry wall, and can be adapted to air conditioning. New units and wall constructions described include the Speedtile, developed by the Wheeler Building Tile Co., Ft. Myers, Fla., the 8- x 8- x 16-in. hollow unit developed

by C. F. Tefft, Claycraft Co., Columbus, Ohio, the metal tied wall designed by Jacob Daniel Brick Co. at Detroit, Mich., and the Farren-Wall, patented by the Western Brick & Supply Co., Lincoln, Neb. E.J.V.

Impressions of largest brick factories in Europe. Fr. Slavík. *Stavivo*, p. 38 (1936).—The London Brick Co. and Forders, Ltd., in Peterborough is described. This is a group of twenty brick factories with a daily production of 5 million brick. R.B.

Pressed brick made of sand mixed with lime as material for building roadways. St. Macan. *Stavivo*, p. 14 (1936).—In 1934 the firm of F. Komnick in Elbing, Germany (since 1930 the firm of F. Schickan), secured the patent for the impregnation with asphalt of pressed brick made of sand and lime. Good results were obtained with the so-called Maxphalt. These impregnated brick come on the market under the names of Bitumensteine, Amalith, Bitukasendsteine, and Vialit. These brick are also manufactured in Czechoslovakia, although not for use in road making. R.B.

PATENT

Preparation of material for making brick, etc. T. C. Fawcett, Ltd., D. L. Fawcett, and A. E. Bottomley. Brit. 451,880, Aug. 26, 1936 (May 17, 1935).

Refractories

Basic brick in Canada. J. W. Craig. *Can. Mining Met. Bull.*, No. 292, pp. 516–30 (1936).—The story of the development of the basic brick industry in Canada is given. G.M.H.

Ceramic insulating materials for high temperatures. W. Weicker. *Elektrotech. Z.*, **56**, 937–39 (1935).—Experimental procedure for the determination of insulating values of ceramic materials in the temperature range 200° to 600°C and several examples of the variation in this value with changing temperature are given. The materials studied were taken from each of the five ceramic groups previously listed (*ibid.*, p. 916), and the results are plotted graphically. See also *Ceram. Abs.*, **15** [8] 248 (1936). F.P.P.

Checker for regenerator chambers. M. K. Mellott. *Steel*, **97**, 42 (Dec. 23, 1935).—The new checker brick is made for any standard size flue, with a brick depth of $2^1/_2$ or 3 in. and a thickness as close to 2 in. as commercially practical. Each checker is interlocked with adjoining checkers at all four corners, and each course of checkers is locked into the adjoining course, thereby preventing shifting or twisting and the obstruction of the flues. Results obtained with the new checker design show an increase of 75% in free area and 23% in heating surface as compared with a standard 9- x $4^1/_2$- x $2^1/_2$-in. brick. The large free horizontal area obtained with the new checker offers a minimum of resistance to the passage of combustion air through the checkers. H.E.S.

Coke-oven repairs. Anon. *Iron & Coal Trades Rev.*, **133** [3567] 57 (1936).—Cracks in furnaces were repaired successfully by spraying cement directly onto the hot brickwork. Procedure, mixture of cement, and equipment are described. M.H.

Comparison of the thermal expansion of used silica brick from an insulated and an uninsulated open-hearth furnace roof. R. H. H. Pierce, Jr., and J. B. Austin. *Jour. Amer. Ceram. Soc.*, **19** [10] 276–87 (1936).

Destruction of refractories through softening and melting. E. T. Richards. *Feuerungstechnik*, **24** [5] 73–77 (1936).—From a theoretical viewpoint, the softening and melting points of refractories depend mainly on (1) the properties of their chief constituents and their impurities; (2) the bond used; (3) production methods, especially firing; (4) load of brick in the hot furnace; (5) foreign materials (slag, gases, etc.) introduced into the brick during operation; (6) porosity of the brick; and (7) resistance of the brick to crumbling. These points are discussed in detail, and the fusing and softening points of pure raw materials and fired refractories with and without load are given in tables. Refractories may be protected from destruction from softening and melting by an appropriate construction of the masonry (especially crowns), cleanliness of the brick surfaces, and protection of the brick from foreign matter by lowering the porosity and treating with pore-closing material, such as an emulsion of alumina powder poor in acid ingredients. Magnesite brick may be immersed in tar oil. See *Ceram. Abs.*, **14** [11] 278 (1935). M.V.C.

"DIN shapes" of refractory brick for furnaces. F. W. H. Wolff. *Feuerungstechnik*, **24** [4] 67 (1936).—W. discusses standard specifications for shapes. Illustrated. M.V.C.

Disintegration of mullitic phases: I-II. Vlad. Škola. *Sklarske Rozhledy*, **13** [2] 23–29; [3] 35–39 (1936).—Mullite decomposes at a temperature below 1810°C, *e.g.*, at 1700°C. Whereas Bowen and Greig (*Jour. Amer. Ceram. Soc.*, **7** [4] 238–54; [5] 410 (1924)) allowed this temperature to act for 30 min. only and did not ascertain any corundum, S. let this temperature react for 8 hr. and ascertained corundum. 7 illustrations. R.B.

Increasing the thermal resistance of brick for coke-oven doors. A. A. Pirogov. *Koks & Khim.*, **5** [7] 53–59 (1935); abstracted in *Chim. & Ind.*, **35** [6] 1364 (1936).—Refractory materials with a grog base are more suitable for lining coke-oven doors than semi-acid materials with quartz and grog base. Grog brick with increased thermal resistance can be obtained by introducing into the charge a high proportion of kaolin or by using pure kaolin. Grog with a grain size of 5 to 6 mm. and with a clay or clay-kaolin base can be used with the same effect. Increasing porosity also increases thermal resistance; in the case of easily fritted clays, a light firing and the incorporation of a small quantity of grog powder have the same effect. M.V.C.

Influence of dimensions of test pieces and rate of heating on the results obtained in the determination of the softening point under load of refractory materials. M. Leroy. *Ing. Chim.*, **19** [112] 186–94; [113] 207–14 (1935); abstracted in *Chim. & Ind.*, **35** [5] 1121 (1936).—Tests made on samples of different dimensions show that for products which break suddenly, *i.e.*, those in which the proportion of fusible binding agent is low, the dimensions have no effect. They are important, however, for those with a higher proportion of binder, the silico-aluminous

materials. They are less important in the case of chromite brick. A test piece 30 x 30 x 50 seems the best. Concerning the rate of heating, the times of 4, 8, and 16°/min. were tried. The intermediate value is preferable. M.V.C.

Manufacture of refractories in Australia. ANON. *Chem. Eng. Mining Rev.*, **28**, 358–60 (July, 1936).—The plants of the Newbold Silica Firebrick Co. at Waratah, Thirroul, and Port Kembla (N.S.W.) are described and illustrated. See *Ceram. Abs.*, **15** [10] 302 (1936). H.H.S.

Manufacturing silica brick of large dimensions. G. BERGAU. *Tonind.-Ztg.*, **60** [43] 845 (1936).—To manufacture large blocks and slabs, B. used (1) (for high grade), 50% Findlings quartzite, 25% rock quartzite, 25% silica brick fragments (fired); (2) (for medium grade), 1/2 Findlings quartzite (2nd grade), 1/3 rock quartzite, 1/3 silica brick fragments; and (3) 50% rock quartzite and 50% silica brick fragments. The refractoriness of the mixes is between cones 34 to 35, 33 to 34, and 32 to 33, respectively. Details of manufacture are given. M.V.C.

Pouring pit refractories and their effect on alloy steel quality. EDWARD E. CALLINAN. *Brick Clay Rec.*, **88** [6] 229–31 (1936); abstracted in *Blast Fur. Steel Plant*, **24** [8] 685–88 (1936).—Molten slag and metal attack refractories exposed to them by chemical action (corrosion) and by mechanical action (erosion). Materials so exposed must not only have ample refractory qualities but must also have the correct physical and chemical properties, to some extent at the expense of the refractory value. Refractories are worn off in amounts dependent on the chemical properties of the slag and steel, their temperatures, and the time the steel remains in the ladle. The greatest erosion and contamination by refractory material occurs at the ladle nozzle. A thorough discussion of ladle brick, nozzles, sleeves, hot tops, and clay plugs is presented to give a better understanding of the requirements of these products. E.J.V.

Properties and performance of silicon carbide batts in the porcelain and other ceramic industries. GRANT S. DIAMOND. *Bull. Amer. Ceram. Soc.*, **15** [9] 297–98 (1936).

Quartz as a devitrification product of vitreous silica. L. J. TROSTEL. *Jour. Amer. Ceram. Soc.*, **19** [10] 271–75 (1936).

Refractory magnesite for cement kilns. JAROSLAV ŠIMÁNĚ. *Stavivo*, p. 94 (1936).—The brick used for this purpose contained 4.56% of alkalis and 1.15% SO_3 which were not present in the layer before being used. Generally, however, the slag does not form on the surface of the magnesite brick, but only when alkalis are present in a greater quantity in the clinker zone. R.B.

Refractory materials used in metallurgy. R. VERNIER. *Métallurgie Construct. Mécan.*, **68** [11] 11–14 (1936); abstracted in *Chem. Zentr.*, ii, 1043 (1936).—The first part deals with (1) the significance of refractories in metallurgy, (2) various properties of refractories, (3) classification, (4) acid and basic refractories, (5) melting point of silica and alumina, (6) materials containing SiO_2, (7) allotropic modifications of silica, and (8) reversible transformation of silica. The second part is devoted to the special treatment of refractories: (*a*) siliceous refractories, (*b*) refractories containing SiO_2 and Al_2O_3, (*c*) bauxite and sillimanite, and (*d*) refractories for basic operations. M.V.C.

Refractory stoneware for basic open-hearth furnaces. L. POMPEI. *Metallurgia Ital.*, **28**, 145–61 (1936); abstracted in *Chem. Zentr.*, ii, 529 (1936).—After enumerating the properties of refractory materials used in open-hearth furnaces, P. describes the physical and chemical properties of the materials used for them. M.V.C.

Relationship between permeability and porosity of refractory materials. ANON. *Het Gas*, **56**, 58–62 (1936); abstracted in *Chem. Zentr.*, ii, 1224 (1936).—A review based on technical literature is presented. M.V.C.

Secondary expansion of flint fire clays. J. OTIS EVERHART. *Brick Clay Rec.*, **89** [1] 28 (1936).—A study of 21 clays from Ohio, Pa., Ky., and Mo. has been made to determine the cause and possible means of control of secondary expansion in refractory brick. Chemical analyses show the better clays to have alumina-silica ratios near that of pure kaolin. The essential difference between better flint and plastic clays is in the mineral structure rather than in the chemical constituents. Up to 30% of a kaolin mineral (probably dickite) is found in some of the flint clays. Two-thirds of the flint clays examined show secondary expansion. The development of parallel cracks in the interior of large grains, which expand as the temperature rises, increased with a reducing kiln atmosphere. Expansion can be reduced by fine grinding of the raw material. E.J.V.

Testing refractories against the corrosive action of electric furnace phosphate slags. GORDON R. POLE AND D. G. MOORE. *Jour. Amer. Ceram. Soc.*, **19** [10] 259–70 (1936).

BOOK

Physical Chemistry of Steelmaking. CHARLES H. HERTY, JR., *et al.* Published by Metallurgical Advisory Board to Carnegie Inst. Tech., Pittsburgh. *Bull.* Nos. 64–69, 328 pp. Price $3.00. Reviewed in *Ind. Eng. Chem., News Ed.*, **13** [11] 251 (1935).—A discussion of refractories and determinations of the melting points and viscosities of slags are included in this volume. F.G.H.

PATENTS

Continuous extraction of aluminium oxide from bauxite. VEREINIGTE ALUMINIUM-WERKE A.-G. Brit. 451,090, Aug. 12, 1936 (Feb. 2, 1935).

Method for separation of aluminium oxide from raw material. K. H. S. LÖFQUIST. U. S. 2,052,236, Aug. 25, 1936 (Dec. 6, 1935). The process of separating aluminium oxide from raw material containing, besides aluminium oxide, mainly silicium dioxide comprises forming a melt containing the raw material and lead oxide in such amounts that the weight content of lead oxide is at least 3.8 times the content of silicium dioxide, cooling the melt slowly, and separating the grains of aluminium oxide formed in the cooling melt from the siliceous ground mass.

Refractories. N. P. PITT, A. C. HALFERDAHL, AND F. E. LATHE. Brit. 450,961, Aug. 12, 1936 (Oct. 27, 1934).

Refractories and method of making. C. L. NORTON, JR. (Babcock & Wilcox Co.). U. S. 2,051,964, Aug. 25, 1936 (Feb. 28, 1935). The method of inducing the formation of mullite crystals in a fired silica-alumina article at low temperatures consists in mixing with the base material a low melting point substance capable of combining with

the elements of the base material to form a succession of glasses having successively higher melting points, and heating the whole until the formation of mullite crystals and glass has progressed sufficiently to give the article requisite strength.

Refractory. F. A. HARVEY AND J. S. MCDOWELL (Harbison-Walker Refractories Co.). U. S. 2,053,146, Sept. 1, 1936 (April 21, 1933). The method of making a chrome ore refractory comprises intimately mixing relatively coarse chrome ore with high-magnesia material in an amount corresponding to about 5 to 30% of MgO, the high-magnesia material being finely divided to substantially completely pass a 70-mesh screen, adding a mineralizer in minor amount to the batch, molding the batch, drying the molded shapes and firing them, and thereby forming a refractory characterized by high softening point, substantial freedom from spalling under thermal shock, and low service shrinkage

Refractory composition. J. M. KNOTE (Quigley Co., Inc.). U. S. 2,051,002, Aug. 11, 1936 (Dec. 23, 1932). A composition for lining a furnace which will be rendered refractory by the heat generated at working temperatures therein comprises about one part by weight of a hydraulic cement having a high content of alumina and one part of crushed and thoroughly sintered dolomite with about five parts of crushed chromite.

Refractory material and method of making. J. M. KNOTE (Quigley Co., Inc.). U. S. 2,051,003, Aug. 11, 1936 (Nov. 28, 1933). A process for preparing refractory linings for metallurgical furnaces and like purposes is characterized by mixing while dry chromite and calcined magnesite containing a relatively large quantity of free magnesia with calcium aluminate cement which contains a high percentage of alumina, sometimes called "fused" cement, the proportions being such that the magnesia content of the mixture shall be large enough to form a magnesia spinel after combining with the alumina of the cement by pyrochemical action, transforming the mixture into solid form at atmospheric temperatures by adding water to hydrate the cement, whereby the finely divided particles of such cement and free magnesia are brought into intimate contact and physical cohesion one with another without the application of pressure to the mass, and further hardening the so-solidified mass by heating it to working furnace temperatures of at least about 2300°F, sufficiently high to drive off the water of hydration and thereafter pyrochemically combine the alumina of the dehydrated cement with the magnesia.

Refractory material and method of making. W. W. TRIGGS AND G. E. SEIL. Brit. 451,493, Aug. 19, 1936 (Nov. 2, 1934).

Terra Cotta

Efflorescence on roofing. JOSEF MATĚJKA. *Stavivo*, p. 116 (1935).—The most frequent cause of efflorescence is the composition of the raw material, the hardness of the water, or the process of production. If the efflorescence is due to the calcium carbonate, the tile does not have a good appearance, but its durability does not suffer thereby. This may happen, however, if the efflorescence is due to sulfates, whether sodium or magnesium, for they crystallize with a greater amount of water, and the crystals not only fill the fine cracks, but their pressure in these cracks causes the crumbling of the tile. Illustrated. R.B.

Firing stove tile. BEDŘICH HELAN. *Stavivo*, p. 62 (1936). R.B.

Formation of bubbles in stoneware pipes. CARL GROVEN. *Tonind.-Ztg.*, **60** [47] 584 (1936).—The formation of bubbles is caused by the presence of iron pyrites in clay and in lignite. The periodic appearance of bubbles without change in the working or composition proves that it is due to the raw clay because iron sulfide and other sulfates are never distributed uniformly but are deposited in nests. M.V.C.

Formation of bubbles in stoneware pipes after firing. ALBERT VASEL. *Tonind.-Ztg.*, **60** [37] 467–68 (1936).—Firing bubbles are produced by a too fat mixture with too finely ground grog and by the method of shaping with a tubular press. Firing does not cause bubbles. M.V.C.

Manufacture of fired roof tile in the brick factory at Horká N/Jizerou. B. HUML. *Stavivo*, p. 93 (1936). R.B.

Manufacture of salt-glazed stoneware pipes and fittings: XIV. A. COULHON. Translated in *Brit. Clayworker*, **45** [531] 104–105 (1936).—Various defects in green pipes, how certain ones may be avoided, and others which it is impossible to avoid are discussed. The origin of the vertical de-airing press and the advantages of de-airing are pointed out. **XV.** *Ibid.*, [532] 142–43.—A vertical de-airing pipe machine, its operation, and the transporting, drying, and fettling of the resulting pipes are described. For Parts **X-XIII** see *Ceram. Abs.*, **15** [10] 305 (1936). R.A.H.

Modern tile stoves. JAN ROLLER. *Stavivo*, p. 66 (1936). R.B.

Production of stove tile. KAREL HINEIS. *Stavivo*, p. 61 (1936). R.B.

Stoneware in Australian sewerage construction. ANON. *Clay Prod. Jour. Australia*, **3** [10] 14–15 (1936).—Sydney's constructional program for the current year includes the laying of 220 miles of stoneware pipes, the bulk being 9 in. in diameter. See *Ceram. Abs.*, **15** [6] 180 (1936). H.H.S.

Tile industry in Australia. J. E. SHILLITO. *Clay Prod. Jour. Australia*, **3** [9] 3, 13–15 (1936).—Australian-made wall tile represent only 26% of the tile used, but in flooring and roofing tile the country supplies 90% of the total used. The wall tile position is regarded as a tariff issue, since three large factories (Australian Tesselated Tile Co., R. Fowler Ltd., and Bakewell Bros.) could supply the home market. Japanese tile, with a duty of $1.00/sq. yd., are being landed at Sydney, papered, at less than the cost of Australian or English tile supplied loose; the cost of papering is estimated at 3¢/sq. yd. in Japan and 30¢ in Australia. H.H.S.

Tiled roofing. VILÉM VLADÍK. *Stavivo*, p. 16 (1936).—A new grooved beaver crown (Czechoslovak Patent Number 50,528), 20 x 40 cm., manufactured by the Ježek

Factory, Blansko, is described. It is a single- or double-grooved tile, the lower end of which is arranged in the shape of a beaver. Illustrated. R.B.

White chemical stoneware. F. SINGER. *Ind. Chemist*, **11**, 376–80 (1935).—"White stoneware," used largely for apparatus, vessels, machines, troughs, channels, pipes, etc., in the manufacture of pharmaceutical products, is a new product which has been discovered through the development of manufacturing technique. The essential difference between this product and ordinary stoneware is the color and the smoother surface of the "white stoneware" glaze. This smooth surface permits easier cleaning and it has less effect on the crystallization of the chemicals. This latter property is of recognized significance for pharmaceutical purposes. As contrasted with porcelain, "white stoneware" can be made in much larger and heavier sizes and at less cost. The nature of the clays and glazes and the chemical durability of the product are also discussed. H.E.S.

BOOK

The Evolving House: Vol. III, Rational Design. ALBERT FARWELL BEMIS. Technology Press, Cambridge, Mass. 625 pp., 110 illustrations. Price $4.00. This book concludes the series of three volumes, of which the first traced the development of shelter from caves to present-day houses and the second analyzed present housing conditions and costs. The third, completed shortly before the author's death, deals with the application of modern production methods to the house. It is devoted to a method of design based upon a simple concept of measurement—the cubical module, which provides a single unit of measurement in all three directions. Houses are essentially rectangular and their volume can be conceived as being made up of a matrix of cubes. The size of these cubes is suggested as conforming to the smallest linear dimension of a house structure, 4 in., which is already more or less established by the stud thickness of an ordinary frame wall. The principles of design and joining of structural frame members, paneling, and other elements of house construction include many original contributions to the art of building.

Because architects sometimes consider that standardized products restrict design, it is shown how coördinated modular standards are an aid to good design rather than a hindrance. Added to this final volume is a summary, with drawings of most of the standardized building efforts being made in this country and abroad, whether in actual production or merely in an experimental form.

This book is of particular interest to manufacturers of structural clay products. Coördinated dimensions of masonry units is referred to as a step in the right direction, but B. suggests, instead of using a variety of building materials as independent foci, first defining structure and adjusting the essential characteristics of each material to meet its requirements. Coördination of modular brickwork with other structural elements of a house is illustrated. This is based on an 8-in. laid-in-the-wall module; 8 in. equals one brick length including the joint, two brick widths including two joints, or three brick thicknesses including three joints. It is suggested that the structural clay products industry might progress toward rationalization by integration and by the reduction of the number of shapes and sizes offered. FREDERICK HEATH, JR.

PATENTS

Manufacture of ornamental brick and apparatus therefor. H. TATTERSALL, JR. Brit. 451,613, Aug. 19, 1936 (March 16, 1935).

Tile construction. AUGUST ROSSI. U. S. 2,053,843, Sept. 8, 1936 (March 23, 1936). A tiled surface construction comprises tile courses alternating with metal purlins, the purlins being secured to a supporting structure and the tile mounted on the purlins, each purlin being provided with an outwardly projecting rib.

Tiled or paneled wall. R. C. WORDEN. U. S. 2,051,064, Aug. 18, 1936 (Aug. 3, 1934).

Whiteware

Alsimag, a new industrial material. AMERICAN LAVA CORP. *Ind. Eng. Chem., News Ed.*, **13** [8] 182 (1935).—Alsimag, a new ceramic composition of practically pure steatite, is designed primarily for the radio and electrical apparatus fields because of exceptional characteristics as an insulating body. It has the following properties: modulus of rupture, 18,600 lb./sq. in.; porosity, less than 0.02% absorption; compressive strength, 79,000 lb./sq. in.; coefficient of thermal expansion at 20°C, 6.37×10^{-6}; hardness, 8 to 8.5; and dielectric strength at room temperature, 200 volts/mil in a disk 0.25 in. thick. Illustrated. F.G.H.

Arcing voltage of soiled insulators. FRITZ OBENHAUS. *Elektrotech. Z.*, **56**, 369–70 (1935).—Methods are given for the design and specification of insulating materials for high-tension plants located in dusty atmospheres. Surface contamination of insulators is particularly undesirable when the covering becomes complete. The relation between the extent of surface covering and the interference in the normal circuit is traced experimentally. F.P.P.

Effect of hydrochloric acid and ammonia on properties of some reworked bodies. ROBERT TWELLS. *Jour. Amer. Ceram. Soc.*, **19** [10] 304–307 (1936).

Expansion of pyrophyllite. A. F. GREAVES-WALKER AND C. W. OWENS, JR. *Bull. Amer. Ceram. Soc.*, **15** [9] 303–305 (1936).

Haban porcelain of Upper Hungary. ARTHUR SCHILLER. *Sprechsaal*, **69** [17] 237 (1936).—S. discusses briefly the Haban porcelain which was developed in the 16th, 17th, and 18th Centuries. The best examples of this artistic porcelain are found in the museums of Prague and Brünn. See *Ceram. Abs.*, **12** [4] 165 (1933). M.V.C.

Measurement of voltage distribution along insulator surfaces. H. SCHERING AND W. RASKE. *Elektrotech. Z.*, **56**, 75–80 (1935).—An electrical treatment of this problem as it affects insulated wires is given. F.P.P.

Porcelain for high-voltage insulators. D. H. ROWLAND. *Elec. Eng.*, **55** [6] 618–26 (1936).—The mechanical failure of porcelain is discussed with special reference to seldom-recognized characteristics: (1) the effect of the porcelain surface on the strength, (2) apparent anomalous distribution of individual mechanical test values, and (3) effect of

time on mechanical strength. A method of evaluating the results of these factors on electrical insulator performance is suggested. Surface strength seems to be of fundamental importance to the proper performance of an insulator dielectric. Tests with variable speeds of load application indicate considerable drop in strength as the loading rate is decreased. G.M.P.

Progress in synthesis of ceramic dielectrics. E. Albers-Schönberg, W. Soyck, and A. Ungewiss. *Elektrotech. Z.*, **56**, 266 (1935).—An electrical insulating material particularly useful for condenser applications is described. Previously used materials have had either too low a dielectric constant or (as with certain rutile-bearing ceramics) sufficiently high dielectric constant but disproportionate leakage or very high negative temperature coefficient of the dielectric constant. The new material, which is silica-free, consists chiefly of alkaline-earth titanates and has the following properties: density, 3.2 g./cm.^{3}; compressive strength, 6000 kg./cm.^{2}; bending strength, 1200 kg./cm.^{2}; linear coefficient of thermal expansion, 9×10^{-6}; and dielectric constant, 15.5. The material is uniformly reproducible. F.P.P.

Spit-out. C. J. Koenig. *Jour. Amer. Ceram. Soc.*, **19** [10] 287–94 (1936).

Syenite in semivitreous ware: I, (*A*) Physical properties of bisques, (*B*) A glaze containing syenite. C. J. Koenig. *Jour. Amer. Ceram. Soc.*, **19** [10] 295–98 (1936).

Table of properties of ceramic materials. W. Weicker, E. Kunstmann, and W. Demuth. *Elektrotech. Z.*, **56**, 915–17 (1935).—A comprehensive and detailed tabulation of ceramic materials and their properties is given. The materials are grouped into five classes, according to composition: (1) porcelains, of intermediate physical properties, (2) steatites, with slight local leakage, high density, and great mechanical strength, (3) materials of high titanium content, with very high dielectric constants, (4) clay-talc bearing materials, with small expansion coefficients and high arcing safety factor, and (5) clay and magnesium silicate-bearing porous materials for electric heating applications. In the tabulations the hard porcelains are subdivided according to the method of preparation and the steatites and Ti-bearing materials according to specialization. The characteristic limits of 18 physical and chemical properties within each group or subgroup are given. See *Ceram. Abs.*, **15** [8] 248 (1936). F.P.P.

Tension measurements of glazed ware by polarization microscope. K. Litzow. *Sprechsaal*, **69** [21] 297–99 (1936).—Tension stresses and pressure strains can be determined and differentiated in glazes with a polarization microscope. Thin sections of the samples are prepared whose planes are put perpendicularly to the glazed surface. The thin section and the specific double refraction of the glaze to be studied must be known to measure strains. The double refraction of four glazes is given. M.V.C.

Transparent whiteware? No, porcelain ware. Josef Wolf. *Sprechsaal*, **69** [23] 325–28; [24] 339–41; [25] 355–59 (1936).—Physical and technological properties indicate ceramic products. Experiments are described in which bodies were produced which show the technological properties of whiteware but which are more or less translucent. The physical and technological properties of these bodies were determined, but the bodies could not be classified according to the classification of H. Hecht. The results of this study show that a body has been found which represents something between whiteware and porcelain, and because of its properties and position in the classification discussed, it is designated as "porcelain ware." M.V.C.

PATENTS

Ceramic bodies forming parts of electric discharge devices. British Thomson-Houston Co., Ltd. Brit. 450,630, Aug. 6, 1936 (Nov. 24, 1934).

Closets or like water-sealed basins or pans. W. C. Groeniger. Brit. 452,338, Sept. 2, 1936 (Oct. 19, 1934).

Lightning arrester. D. R. Kellogg (Westinghouse Electric & Mfg. Co.). U. S. 2,050,334, Aug. 11, 1936 (April 8, 1933).

Pothead device. G. P. Edmonds (G & W Electric Specialty Co.). U. S. 2,050,293, Aug. 11, 1936 (Jan. 8, 1930). U. S. 2,050,294, Aug. 11, 1936 (Jan. 17, 1931).

Pottery finishing lathe. A. A. Wells (Homer Laughlin China Co.). U. S. 2,051,662, Aug. 18, 1936 (Jan. 10, 1934).

Spark plug and method of making. J. A. Jeffery (Champion Spark Plug Co.). U. S. 2,053,369, Sept. 8, 1936 (June 24, 1931). A spark plug comprises an insulating body having the portion at the sparking end of the plug composed of approximately pure sintered magnesium oxide.

Equipment and Apparatus

Basic principles of the drying operation. R. K. Hursh. Presented at Clay Product Plant Operators' Conference, Urbana, Ill., June, 1936; abstracted in *Brick Clay Rec.*, **89** [1] 14–15 (1936). E.J.V.

Christiansen filters. Geo. Abier. *Compt. Rend.*, **202** [21] 1775–77 (1936).—The monochromatic Christiansen filter consists of a small cell containing glass powder which has been rendered transparent by immersion in a liquid of the same refractive index; the dispersion of the glass and the liquid must, however, be as different as possible in order to obtain a narrow transmission band. The liquid should have a small expansion coefficient. Bromomercurate and iodomercurate are suitable solutions. Illustrated. M.H.

Constant-flow orifice meters of low capacity. R. T. Page. *Ind. Eng. Chem., Anal. Ed.*, **7** [5] 355–58 (1935).—The development of a set of constant-flow orifices for laboratory use is described, and the characteristics of the orifices are studied. Illustrated. F.G.H.

Continuous mixer. R. Bennet. *Ind. Chemist*, **11**, 493–94 (1935).—A new type mixer, manufactured by J. Harrison Carter, Ltd., Dunstable, which avoids the objectionable features of the "batch" type mixer is described and illustrated. It consists of two rotating disks mounted one above the other on a central spindle. Each disk is fed from its particular hopper. In operation, fan-like films of the material are thrown off from the rotating disks at a constant rate, and these films, impinging on one another, are

intimately mixed and fall to the bottom of the vessel where they are discharged either by a scraper or from a conical bottom. If three materials are to be mixed, three disks are used. Two types of machines are manufactured, one for mixing granular materials and the other, with very fine adjustments, for mixing chemicals. H.E.S.

De-airing. WAYNE E. BARRETT. Presented at Clay Product Plant Operators' Conference, Urbana, Ill., June, 1936; abstracted in *Brick Clay Rec.*, **89** [1] 14 (1936). E.J.V.

Drying of fine ceramic materials. T. H. TIVES. *Keram. Rundschau*, **42** [43] 536–38 (1934).—Mechanically bound water may vary between 5 and 30%; it is retained in three ways: (1) in the pores, (2) adhered as a film around particles, and (3) in colloidal components. Elimination of water proceeds in three stages: (1) pore water evaporates and particles get nearer to each other, thus giving ordinary drying shrinkage; (2) adherence water disappears slowly, provoking a secondary small shrinkage; and (3) elimination of swelling water gives a final shrinkage. When the bringing together of ceramic particles is sufficiently realized, according to fineness and constitution of grains, perfect drying is secured although it is not yet complete; there is no further shrinkage. For porcelain mixes, this occurs after elimination of 9 to 11% moisture. To prevent cracks, drying must proceed regularly and not more quickly than the movement of water from the inner part to the surface. The correct process is as follows: (1) heating at the correct temperature with damp air, (2) drying at the correct temperature by reducing the air moisture progressively until the end of shrinkage, (3) accelerating the final drying. Shrinkage must be controlled on test pieces of required thickness. T. discusses types of driers (stationary and continuous). The latter type is the best for large production of uniform ware. In some cases, hair cracks were caused by physical transformations in the absence of shrinkage. F.E.V.

Drying of solids. A. H. LOVELESS. *Ind. Chemist*, **11**, 427–35 (1935).—The wide range of materials to which drying processes are applied and the range of conditions obtaining have led to the development of plants having numerous modifications to suit specific local conditions. The choice of plant is influenced by (1) character of the feed, (2) product required and the effect of variation in properties upon its market value, and (3) the tonnage to be handled, as well as local considerations of power and fuel costs and water supply. L. gives an outline of the principles involved in drying operations and the methods available, together with a brief description of the main features of plants representing definite types and their characteristics in operation. H.E.S.

Electromagnetic theory of coaxial transmission lines and cylindrical shields. S. A. SCHELKUNOFF. *Bell System Tech. Jour.*, **13** [4] 532–79 (1934).—A form of circuit of considerable interest for the transmission of high-frequency currents consists of a cylindrical conducting tube within which a smaller conductor is coaxially placed. S. deals generally with the transmission theory of coaxial circuits and extends the theory beyond the range of present application both as to structure and frequency. H.E.S.

Exhaust systems for dusts and gases. TH. HATCH. *Ind. Heating*, **3** [8] 509–11 (1936).—Dangers in industrial activities from dust explosions and dust diseases are discussed, and the protective measures which are recommended by the Committee on Safety Code for Exhaust Systems are described. M.H.

Frantz Ferro filter. SEPARATIONS ENGINEERING CORP. *Ind. Eng. Chem., News Ed.*, **13** [14] 310 (1935).—A magnetic separator for the separation of iron and other magnetic impurities from slips, glazes, enamels, and slurries is described and illustrated. It is made in three sizes, handling 100, 900, and 2350 gal./hr. of fairly viscous slip. F.G.H.

History of ball mills. VIELHABER. *Emailwaren-Ind.*, **13** [25] 211–12 (1936).—A brief review of the development of ball mills is given. M.V.C.

Improvements in quartz crystal circuit elements. F. R. LACK, G. W. WILLARD, AND I. E. FAIR. *Bell System Tech. Jour.*, **13** [3] 453–63 (1934).—The characteristics of the Y-cut quartz crystal plate are discussed. By rotating a plate about the X axis, special orientations are found for which the frequency spectrum is simplified, the temperature coefficient of frequency is reduced practically to zero, and the amount of power that can be controlled without fracture of the crystal is increased. These improvements are obtained without sacrificing the advantages of the Y-cut plate, *i.e.*, activity and the possibility of rigid clamping in the holder. H.E.S.

Influence of testing conditions on shrinkage measurements. O. BAUER AND H. SIEGLERSCHMIDT. *Metallwirtschaft*, **15** [24] 535–40 (1936).—Suggestions for a standard procedure are made. 12 references. See *Ceram. Abs.*, **15** [3] 85 (1936). M.H.

"Jestavky" in foreign countries. K. JEŽEK. *Stavivo*, p. 376 (1935).—"Jestavky" are hollow, pentagonally enclosed brick pressed into rubber molds of the blocks and cut off on a brick press. The K. & A. Ježek factory, Blansko, Czechoslovakia, supplies the presses for the manufacture of "Jestavky," not only in Czechoslovakia but also abroad. 6 illustrations. R.B.

Measurement of radiation loss in the boiler house. F. W. WESTENDORP. *Brennstoff & Wärmewirt.*, **18** [1] 1–6 (1936).—An indirect method of accurately calculating radiation losses in grate boilers, based on a no-load assumption, is described. With two examples it is shown how a reliable performance safety factor may be obtained. F.P.P.

Methods and instruments of industrial temperature measurement and control: II. R. BOYE. *Eng. Progress*, **17** [6] 135–39 (1936).—Types and forms of thermocouples and appropriate indicating and recording apparatus are described. Radiation pyrometers are discussed in detail. 15 figures. For Part I see *Ceram. Abs.*, **15** [10] 310 (1936). J.L.G.

New method to decompose and de-air clays. K. O. SCHULZ. *Tonind.-Ztg.*, **60** [44–45] 557 (1936).—The method is based on the decomposition and de-airing of clay with steam and subsequent cooling without air but with different steam tensions. M.V.C.

Operation and control of driers. A. P. POTTS. Presented at Clay Product Plant Operators' Conference, Urbana, Ill., June, 1936; abstracted in *Brick Clay Rec.*, **89** [1] 15 (1936). E.J.V.

Protective appliances. THOMAS A. WILSON. *Welding*

Jour. [New York], **15** [7] 6–18 (1936).—Eye protection with goggles and helmets for various classes of welding and cutting is discussed. Satisfactory protection is possible by following Federal or Navy specifications for glass shades. Requirements for safe ventilation are reviewed, and a brief discussion of health hazards present during arc and gas welding is given. Ventilation with exhaust hoods, suction tubes near the work, and the wearing of respirators are discussed. The supplied-air respirator is considered safest for the welder. A filter-type respirator should contain both a mechanical filter for dust and smoke and a chemical filter for noxious gases. W.H.B.

Pugging. H. R. Straight. Presented at Clay Product Plant Operator's Conference, Urbana, Ill., June, 1936; abstracted in *Brick Clay Rec.*, **89** [1] 15 (1936). E.J.V.

Rapid micro-method for the determination of melting point. R. C. Ray and V. Dayal. *Trans. Faraday Soc.*, **32** [5] 741–43 (1936).—A platinum point formed by a bent platinum wire is made to touch a tiny particle of the solid whose fusion is observed through a telescope. The platinum point is heated by current from a storage battery. Having calibrated the apparatus by fusing solids of known melting points, it is necessary to measure the current passing through the platinum point when the unknown substance just begins to melt. G.R.S.

Reflection and translucency. W. P. Digby. *Elec. Rev.*, **119** [3063] 181 (1936).—The apparatus described is a modification of the reflection meter made by Edgcumbe & Co., Ltd. One pair of photoelectric cells in the upper compartment of the instrument measures the light reflected vertically either from a standard reference material or from the unknown. Another pair of photoelectric cells located below the unknown material measures the light transmitted from the same standard source used in the reflection measurement. A simple switching arrangement utilizes the same microammeter for both measurements. A sheet of white paper had a reflection value of 74 and a transmission of 24.5. The reflection meter has been used for investigating the tarnishing of metals and the fading of paint. The modification has been applied to the testing of aircraft linens. J.L.G.

Simple rotating ball mill. Arthur H. Furnstal. *Ind. Eng. Chem., Anal. Ed.*, **7** [5] 342–43 (1935).—The design and construction of a compact, efficient, and portable ball mill are described and illustrated. F.G.H.

Spray-drying process: some possible applications to ceramics. Robert Twells. *Bull. Amer. Ceram. Soc.*, **15** [9] 311–13 (1936).

Thermal and electrical conductivity of metals and alloys: II, Some heat-resistant alloys from 0°C to 800°C. R. W. Powell. *Proc. Phys. Soc.* [London], **48** [3] 381–92 (1936).—Measurements were made on stainless steel, Monel metal, and an alloy composed of approximately 80% nickel and 20% chromium. For Part I see *Ceram. Abs.*, **14** [11] 294 (1935). L.E.T.

Vacuum-tube electronics at ultra-high frequencies. F. B. Llewellyn. *Bell System Tech. Jour.*, **13** [1] 59–101 (1934).—Vacuum-tube electronics are analyzed when the time of flight of the electrons is taken into account. The analysis starts with a known current which, in general, consists of d.-c. value plus a number of a.-c. components. The velocities of the electrons are associated with corresponding current components, and from these velocities the potential differences are computed, so that the final result may be expressed in the form of an impedance. Applications of the general analysis are made to diodes, triodes with negative grid, and triodes with positive grid and either negative or positive plate, which constitute the Birkhausen type of ultrahigh-frequency oscillator. A wave-length range extending from infinity down to only a few centimeters is considered, and it is shown that even in the low-frequency range certain slight modifications should be made in the usual analysis of negative grid triode. Oscillation conditions for positive grid triodes are indicated, and a brief discussion of the general assumption made in the theory is appended. H.E.S.

Velocity and temperature curves of the drying process. A. W. Lykow. *Kolloid-Z.*, **71** [1] 103–11 (1935).—Based on experimental evidence, mathematical consideration of drying curves of peat, brown coal, chrome leather, and clay is presented. Two critical moisture contents were observed for all materials. Their locations depend on the thickness and nature of the material, but the gap between them remains approximately constant whatever the rate of drying. With many materials such as clay, shrinking occurs before actual drying begins and is associated with the first critical point. With other materials, shrinking occurs during the entire drying process. See "Relationship—" *Ceram. Abs.*, **15** [8] 251 (1936). F.P.P.

Vertical pipe de-airing machine. Anon. *Clay Prod. Jour. Australia*, **3** [9] 31 (1936).—The first de-airing machinery to be made in Australia is that of J. Welsh, Carlton, Melbourne. The new vertical machine is described. H.H.S.

BOOKS

A.S.T.M. Standards on Petroleum Products and Lubricants. Committee D-2 on Petroleum Products and Lubricants. Published by American Society for Testing Materials, Philadelphia, Pa., 1935. 358 pp. Price $1.75. Reviewed in *Ind. Eng. Chem., News Ed.*, **13** [22] 447 (1935). F.G.H.

Chemical Engineering Technology: Vol. III. (Chemische Ingenieur-Technik). Ernst Berl. Julius Springer, Berlin, 1935. 580 pp. Price 80 Rm. Reviewed in *Ind. Eng. Chem., News Ed.*, **13** [16] 339 (1935).—The third and last volume of this work includes chapters on (1) crushing and grinding, (2) screens and screening, (3) sedimentation, decanting, and hydraulic separation, (4) ore dressing and flotation, (5) agitation, (6) mixing, (7) kneading, (8) filtration, and (9) the colloid chemistry of suspensions with consideration of their particle-size reduction. For Vol. II see this issue, p. 343. F.G.H.

Crushers for Stone and Ore. Their Development, Characteristics, and Capabilities. William T. W. Miller. Mining Publications, Ltd., London, 1935. 234 pp. Price 15s. Reviewed in *Ind. Eng. Chem., News Ed.*, **13** [12] 268 (1935).—This book presents a practical engineering treatment of the construction and operation of coarse and intermediate crushers but does not touch the field of pulverization. The jaw crusher and the gyratory crusher are discussed as sledges and as secondary breakers, and their respective merits are compared. Rolls, disks, and swing-hammer crushers are also included. The treatment of each

includes design, materials for wearing parts, mechanism, bearings, adjusting devices, and lubrication. Concluding chapters cover the choice of a crusher and screen analyses of crusher products. The screen analyses indicate that the products considered are at least 80 to 90% coarser than 1/8 in. F.G.H.

1935 Instruments Index. ANON. Instruments Publishing Co., Pittsburgh, Pa., 1935. 29 pp. Reviewed in *Ind. Eng. Chem., News Ed.*, **13** [15] 325 (1935). F.G.H.

PATENTS

Continuous filter. N. H. HILLER AND E. B. MCCABE (Worthington Pump and Machinery Corp.). U. S. 2,053,664, Sept. 8, 1936 (June 20, 1934).

Devices for blowing granular particles onto surfaces. JOSEPH DIXON CRUCIBLE CO. Brit. 452,399, Sept. 2, 1936 (Feb. 4, 1935).

Machine for milling moist or dry potters' clay, marl, etc., into powder, graded as required. T. GROCOTT AND W. GROCOTT (trading as Gaskell & Grocott). Brit. 451,957, Aug. 26, 1936 (Feb. 15, 1935).

Protection of cast iron and steel against oxidation at high temperature. SOC. ANON. DES HAUTS-FOURNEAUX DE LA CHIERS. Brit. 451,472, Aug. 19, 1936 (Nov. 21, 1934).

Smelting furnace. P. L. C. BLANCHARD, M. H. V. DELOT, AND R. A. PIGAL. U. S. 2,053,652, Sept. 8, 1936 (Jan. 12, 1935).

Kilns, Furnaces, Fuels, and Combustion

Analysis of fuel in technical plants. K. SCHULTZE AND F. H. ZSCHACKE. *Glashütte*, **66** [26] 441–44; [28] 479–82 (1936).—After a general discussion of various types of fuel used in glass and enamel works, solid fuel is discussed with regard to (1) sampling, (2) determining grain size, (3) moisture, (4) ashes, (5) melting point of ashes, and (6) Bochum coking method. M.V.C.

Calculating lateral pressure in furnace crowns on heating. JULIUS LAMORT. *Glashütte*, **66** [21] 363–64 (1936).—Examples of simple calculation to determine the lateral pressure in furnace crowns when cold and when heated are given. M.V.C.

Characteristics of fuel oils. OTTO LUTHERER. *Enamelist*, **13** [8] 8–11 (1936).—Charts based on the latest engineering data show the various characteristics of fuel oil, including specific gravity, viscosity, preheat temperatures, flash point, and B.t.u. per gallon. E.J.V.

Chinese kilns that last for two firings. HENRY JEWITT GREENE. *Bull. Amer. Ceram. Soc.*, **15** [9] 323 (1936).

Circular tunnel kilns. Defects of tunnel kilns. ANON. *Sprechsaal*, **69** [22] 309–10 (1936).—Various defects of tunnel kilns are enumerated, and circular tunnel kilns used in the U.S. and England are described. Illustrated. M.V.C.

Determining the specific gravity of gases. Improvements in the effusion method. L. C. KEMP, JR., J. F. COLLINS, JR., AND W. E. KUHN. *Ind. Eng. Chem., Anal. Ed.*, **7** [5] 338–41 (1935).—The minimization of inherent errors in the effusion method for determining the specific gravity of gases is studied. The results obtained warrant the acceptance for routine work of gas specific gravities below 1.30 obtained by the effusion method, employing an enlarged gas chamber and corrected by means of a correlation of the apparatus being used with a specific gravity balance. The probable accuracy so obtained is within 2.5%. Values above 1.30 may be used, but the probable accuracy is considerably lessened above that figure. The data, although not entirely conclusive, indicate that the orifice plate should have a thickness of less than 0.10 mm. and probably above 0.05 mm. The diameter should be approximately 0.240 mm. and should not exceed 0.260. Below 0.20-mm. diameter difficulty is encountered in obtaining a satisfactory opening. Stainless steel is recommended as an acceptable substitute for platinum in making the orifice plate for service where stainless steel will withstand the corrosive agents present. F.G.H.

Device for finding tar in generator gas. L. FEJLEK. *Sklarske Rozhledy*, **13** [1] 9–10 (1936).—A description of the apparatus constructed by the State Institute for the Economic Utilization of Fuels in Prague is given. The apparatus was constructed by the A. Kreidl Company. In contrast to that of Maurach, this apparatus has certain advantages, especially in its simplicity. The tar is condensed with water-vapor in a glass globe which is cooled by water, the condensed part remaining in the cotton filter in the neck of the globe. The water is caught and determined in the V-tube with $CaCl_2$. The water in the globe is determined through distillation with xylol, and the tar is determined from the difference. A simple gas meter was constructed to measure the volume of gases. Illustrated. R.B.

Effect of heat on clays. T. N. MCVAY. Presented at Clay Product Plant Operators' Conference, Urbana, Ill., June, 1936; abstracted in *Brick Clay Rec.*, **89** [1] 15 (1936). E.J.V.

Factors influencing the properties of semicoke. JOHN ROBERTS. *Colliery Eng.*, **11** [11] 379–82 (1934).—R. discusses the critical temperature, ignition temperature, influence of H on the ignition point, influence of graphitic carbon, electrical conductivity of coke, and influence of the ingredients in coals and coal blends. A.P.S.

Failure of a brick chimney. Damage to a brick stack due to excessive fuel consumption. ANON. *Eng. Boiler House Rev.*, **49** [7] 504 (1935).—A Lancashire boiler 8 ft. in diameter by 30 ft. long had the usual brick setting with a main flue about 20 ft. long connecting direct to the chimney base, the chimney being located at right angles to the rear of the boiler. The chimney was of round construction with a base diameter of 8 ft. and a total height of 60 ft., being lined internally with 4 1/2 in. thick refractory for a height of 16 ft. without air space. The general appearance was of a solid and sturdy construction. It was placed in commission about four years ago, the boiler having then been in operation for about twelve years with a gradually increasing load. The plant consumed about 560 lb. of coal per hour when the new chimney was constructed. The coal used was clean and had a volatile content of about 33%. The steam demands were in-

creased about 20% during the first 12 months, but the fuel consumption considerably exceeded this figure, causing a great deal of smoke; at times flames were visible at the top of the chimney. Forced-draft furnaces of the steam-jet operated type without any secondary air supply were used. Cracks soon developed in the lower part of the chimney, causing the flames to extrude through them. Although these cracks were filled in, the filling would not hold, and they generally developed into three main vertical openings spaced around the chimney, each being about 2 in. average width and extending from the base to a height of about 15 ft. The coal consumption was increased to about 900 lb./hr. in order to meet the steam demands. When there was a heavy wind, a swaying movement of about 18 in. from the vertical was observed. It was at last decided to demolish the stack for safety. W.F.F.

Heat distribution. R. K. Hursh. Presented at Clay Product Plant Operators' Conference, Urbana, Ill., June, 1936; abstracted in *Brick Clay Rec.*, **89** [1] 14 (1936). E.J.V.

Improving old kilns. Anon. *Brit. Clayworker*, **45** [531] 109 (1936).—Many of the older continuous circular kilns were built without sufficient knowledge of kiln design. One of the chief causes of low output is shortness. The effective length or total distance of fire travel should not be less than 240 to 300 ft. Lengthening of the kilns or allowing only dry ware to enter them is suggested. Kilns which are excessively long should be corrected by using fans or should be fired as two separate kilns. R.A.H.

Increasing kiln output. Alfred B. Searle. *Brit. Clayworker*, **45** [532] 154 (1936).—The brick must be dry before entering the kiln and should not be set too closely. A long fire zone is essential and the coal used must be dry. Automatic stokers usually increase and leaking kiln caps reduce the output. A separate fan to remove steam and combined water, if the kiln is sufficiently long, and a chimney draft of 0.8-in. water gage will also increase output. Perfect uniformity of operation is the most certain means of obtaining the maximum output of which a kiln is capable. R.A.H.

Industrial propane used for many different purposes at steel foundry. W. Z. Friend and E. A. Jamison. *Steel*, **97**, 56–58 (Sept. 23, 1935).—Many new uses for industrial propane are given. Oxypropane torches are used in cutting risers from castings. The flame temperature of a mixture of oxygen and propane is said to melt a minimum amount of metal on each side of the flame. Propane is also being used to heat core ovens and for mold drying, car bottom-type annealing furnaces, high-temperature oven furnaces, brazing torches, boiler furnaces, and cafeteria ovens. The gas is used at pressures varying from 15-in. water pressure to 30 lb. without the use of compressors, boosters, and associated control equipment. H.E.S.

Method for calculating the heating value of technical fuels. Marcus Brutzcus. *Compt. Rend.*, **200** [26] 1268–70 (1935).—The formula of Dulong, heating value = (8080 C − 34,500 (H − 1/80) + 2500 S)/100 cal., is used to calculate a number of liquid fuels of various origins. The deviations from the values found by experiment are not greater than 8%, in average about 3 to 4%. A table shows compositions, specific weights, and O required for combustion for 1 kg. oil. M.H.

Methods of firing control. V. W. Boeker. *Brick Clay Rec.*, **89** [1] 18–20 (1936).—The various steps in firing are (1) watersmoking, (2) oxidation, (3) heat-raising, (4) soaking, (5) flashing, and (6) cooling. The first factor that requires consideration in controlling firing is the draft, which may be induced or forced. Means of draft control are discussed. Measurement and control of temperature by pyrometric cones and pyrometers are taken up. Control of excess air, flashing, and cooling are discussed. E.J.V.

Recuperators. F. T. *Verre & Silicates Ind.*, **7** [16] 188–89 (1936).—Both the horizontally and vertically mounted Teisen recuperators are absolutely tight, the choice depending on the type of furnace. Questions of surface of contact, dust, blast, etc., are discussed. M.V.C.

Selection of coal for underfeed stokers. R. L. Rowan *et al.* Presented at meeting of Amer. Soc. Mech. Engrs., Dec., 1935; abstracted in *Combustion*, **7** [5] 33–37 (1935).—The purpose of the paper is to point out the complexity of the problem of selecting coals for underfeed stokers. It does not attempt to present a method or a formula for such selection, but aims to stimulate discussion. H.E.S.

Smoke question: I. Anon. *Brit. Clayworker*, **45** [532] 147–49 (1936).—A discussion of furnace design with respect to downdraft kilns and the difficulty of avoiding the issuance of heavy smoke through the watersmoking period is given. The remedy suggested is the use of coke during the earlier period of firing. R.A.H.

Smokeless downdraft kiln. Anon. *Brit. Clayworker*, **45** [531] 106–108 (1936).—The elimination of smoke in downdraft kilns and the advantages gained are discussed. R.A.H.

Sulfur elimination from flue gases. Anon. *Ind. Chemist*, **11**, 111–15, 149–52, 214–19, 336–42 (1935).—To eliminate the noxious materials discharged into the air from a large generating station, a gas washer was designed and installed. Details and illustrations of the installation are given. H.E.S.

Thermal protection when building electric furnaces. Otto Krebs. *Feuerungstechnik*, **23** [5] 54–55 (1935).—Thermal losses through furnace walls are discussed in detail. Illustrated. M.V.C.

Wet purification of coke-oven gas. H. A. J. Pieters. *Iron & Coal Trades Rev.*, **133** [3571] 211 (1936).—In the carbonization process of coal the pyrites are decomposed; the organic S compounds of coal, the volatile decomposition products of which contaminate the gas, must be eliminated. Processes and apparatus for this purpose are described. M.H.

BOOKS

Analysis and Handling of Gases. Augustus H. Gill. Edward Brothers, Inc., Ann Arbor, Mich., 1935. 71 pp. Price $2.00. Reviewed in *Ind. Eng. Chem., News Ed.*, **13** [16] 339 (1935). F.G.H.

Chemical Engineering Technology: Vol. II (Chemische Ingenieur-Technik). Ernst Berl. Julius Springer, Berlin, 1935. 795 pp. Price 110 Rm. Reviewed in *Ind. Eng. Chem., News Ed.*, **13** [12] 267 (1935).—Chapters on industrial furnaces and electrical furnaces are included in this volume. For Vol. III see this issue, p 341. F.G.H.

Chemical investigation of silicon carbide heating elements. H. KLAMMROTH. *Mitt. Forschungsinst. für Electrowärmetech.* [Hannover], No. 15 (1935). 48 pp. Price 1.90 Rm; abstracted in *Referat. Silikatliteratur*, No. 2812 (1936).—Heating elements of SiC are attacked by air at 1400°C with oxidizing of the silica and carbon. The reaction occurs on the surface of the SiC particles. A coat of SiO_2 is formed which prevents the penetration of O and the progress of combustion. The SiC material becomes lighter in color and more brittle. The electrical resistance increases with time. The density decreases and silica concentrates between particles. The newly formed SiO_2 consists of cristobalite which changes in volume with temperature fluctuations and destroys the structure. Pure O promotes the oxidizing of SiC. In pure nitrogen silicon nitrides are formed and CN_2 is separated. See *Ceram. Abs.*, **15** [3] 102 (1936). M.V.C.

Electric Furnaces—Progress of chemical apparatus (Elektrische Öfen—Fortschütte des chemischer apparatewesens). ADOLF BRAÜER AND JOSEF REITSTÖTTER. Akademische Verlagsges.m.b.H., Leipzig, 1931–36. Reviewed in *Brit. Clayworker*, **45** [532] 162 (1936).—In conjunction with H. Alterthum and with the collaboration of several colleagues, the authors have brought out, between 1931 and 1936, a collective work on electric furnaces. Their presentation deals mainly with German patents. In recent years, electrically heated periodic and tunnel kilns have found favor and proved excellent. The ceramic industry has another interest in this book since refractory linings for electric and other furnaces are discussed. See *Ceram. Abs.*, **15** [3] 103; [4] 130 (1936). R.A.H.

Textbook of American Gas Practice: Vol. II, Distribution and Utilization of City Gas. JEROME J. MORGAN. Jerome J. Morgan, Maplewood, N. J., 1935. 1031 pp. Price $8.00. Reviewed in *Ind. Eng. Chem., News Ed.*, **13** [10] 235 (1935).—M. discusses the transmission, distribution, and utilization of natural gas and of manufactured gas in a comprehensive manner. Discussions of the theory and problems illustrating the applications of many recent developments in the transmission and distribution of city gas and in the utilization of gaseous fuels have been included. P.G.H.

PATENTS

Art of ceramic kilning and making building units. H. G. THOMSON. U. S. 2,052,324, Aug. 25, 1936 (Feb. 25, 1933). The combination, with a kiln, of a movable hearth operating through a portion thereof, a series of transversely channelled reflecting surfaces spaced along the path of movement of the hearth at successively increasing heights thereabove, heaters operatively associated with the respective reflectors for the radiation of their heat toward the hearth and materials carried thereby, a series of preheaters, and a distributing feeder leading from each preheater toward the hearth and including means for delivering preheated material in a thin film throughout a predetermined area of the hearth, one of the feeders being placed immediately before each heater whereby successive increments of material upon the hearth will be successively exposed to like conditions of heat.

Tunnel kiln. J. J. SCHARP AND L. T. STROMMER (Libbey-Owens-Ford Glass Co.). U. S. 2,053,497, Sept. 8, 1936 (Aug. 7, 1934). In a tunnel kiln construction, a tunnel structure includes a main heating zone and an auxiliary heating zone in substantial alignment with one another, means for carrying the work to be treated through the zones, means for heating the main heating zone, and means for receiving a portion of the heat from the main heating zone and introducing it into opposite sides of the auxiliary heating zone adjacent the bottom thereof.

Geology

Andalusite used in making spark plugs. ANON. *New York Times*, June 14, 1936.—Andalusite can be made into a porcelain which will stand extreme heat and pressure and also act as an insulator. For this reason, andalusite is excellent for spark plugs. M.V.C.

Apparatus for carbonic acid estimations in soils. B. N. SINGH AND P. B. MATHUR. *Soil Sci.*, **41** [6] 433–41 (1936).—A new apparatus for the estimation of carbonic acid in soils is described. In its construction the use of rubber connections, which are likely to cause errors in various ways, has been avoided, and an effective mixing of reactants rendered practicable. Because of its detachable nature, the reaction bulb is easily shaken by hand, and no shaking apparatus is required. The accuracy of the apparatus, as found in practice, is ±1.25%. A few experimental data are presented. Illustrated by photographs and diagrams. G.R.S.

Chilean nitrate. ANON. *Enamelist*, **13** [9] 43–44 (1936).—Chilean nitrate, a natural nitrate of soda found in deposits in the Chilean pampas, is used in the manufacture of frit as a strong oxidizing agent. As excessive amounts cause frothing, only a sufficient quantity to maintain proper oxidizing conditions is used. E.J.V.

Clays in parts of the Bangalore, Nelamangala, Tiptur, and Gubbi taluks. S. L. RAO. *Rec. Mysore Geol. Dept.*, **32**, 35–50 (1934).—The clays have been formed by the weathering of numerous pegmatite veins in gneiss. Some 600,000 tons of clay are available for manufacturing Portland cement. A.P.S.

Clays for stoneware manufacture. M. B. R. RAO. *Rec. Mysore Geol. Dept.*, **32**, 70–75 (1934).—Some of the clays are derived from decomposition of gneiss and others are of alluvial origin. A.P.S.

Cobalt oxide. S. B. WRIGHT. *Enamelist*, **13** [6] 42–43 (1936).—The silver-cobalt ores of the Cobalt district in northern Ontario were the greatest source of cobalt until the development of deposits in the Belgian Congo and Rhodesia. The silver-cobalt ore, containing 20 to 50% arsenic, is smelted to a speiss, into which silver, cobalt, and nickel are concentrated. Roasting eliminates arsenic, cyaniding extracts the silver, and the cobalt and nickel are converted to sulfates by means of sulfuric acid. After separation of copper and iron from the sulfate solution, the cobalt is fractionally precipitated by means of hypochlorites in the form of cobalt hydroxides, calcination of which produces black cobalt oxide used in the manufacture of porcelain enamel frits. E.J.V.

Composition and ionic exchange of ferric silicates and

phosphates. A. J. Pugh and M. S. du Toit. *Soil Sci.*, **41** [6] 417–31 (1936).—Adsorption of sulfate diminishes with increasing acidoid content of the colloid. The ferric silicates have an optimum ratio at which the base exchange is a maximum. The hydroxyl ion displaces the SiO_3 and PO_4 ions in equivalent proportions. The application of the isoelectric point and the theory of amphoteric electrolytes to the interpretation of ionic exchange is discussed. G.R.S.

Cryolite as a chemical raw material. A. E. Gibbs. *Chem. Industries*, **38** [5] 471–76 (1936).—Cryolite is used in enamels, glass, glazes, and as a flux in galvanizing, etc. In enamel work it increases the rate of interaction of the other ingredients in the smelting furnace by reason of its fluxing action and also behaves as a secondary opacifying agent. The quantity used varies from 4 to 16%. In glass manufacture the chief value of cryolite lies in its opacifying effect rather than its fluxing action. In glazes it has much the same effect. Cryolite is also used as a binder for granular materials such as abrasives, as an electrical insulator material, and as an insecticide. A detailed description of the preparation and properties of cryolite is given. Its specific weight is 2.96, and its hardness between 2.5 and 3; it is almost insoluble in water, it fuses at 950°C, and is made up of about 33% sodium, 13% alumina, and 54% fluorine. M.J.H.

Diatomaceous earth. Anon. *Enamelist*, **13** [8] 41–44 (1936).—Diatomaceous earth, fossilized deposits of the microscopic plant known as the diatom, has the unique combination of low thermal conductivity, high porosity, high absorptive capacity, extreme hardness, and indestructibility. It is used for thermal insulation from 1000° to 2500°. The methods of production are described. E.J.V.

Dubriniče kaolin. O. Kallauner, J. Alejnikov, and L. Matoušek. *Stavivo*, p. 49 (1936).—This is a kaolin of Dubriniče near Berehov. The content of the kaolinite is 32%. Illustrated. R.B.

Dutch bauxite. Anon. *Can. Mining Jour.*, **57** [8] 381 (1936).—Bauxite occurs in the Rhio archipelago of Netherlands India, most extensively on Bintam Island south of Singapore. These deposits are of good quality though not particularly uniform. Development is taking place, largely to supply Japanese interests. G.M.H.

Feldspar as a chemical raw material. D. E. Sharp and A. K. Lyle. *Chem. Industries*, **38** [3] 248–52 (1936).—Almost 90% of the feldspar used in the U.S. is accounted for by the ceramic and glass industries, the glass industry taking the largest single amount; 10% is used in the production of scouring soaps, abrasives, and similar miscellaneous items. Feldspar consists mainly of silica, about 17% of alumina, and about 13% of sodium and potassium. Two main varieties enter into the composition of commercial feldspars, sodium, and potassium, the microcline and orthoclase types being outstanding in the potassium group and albite being the principal one of the sodium group. The glass manufacturer is interested chiefly in the alumina content of feldspar, and the whiteware manufacturer is most concerned with its content of fluxes together with the constancy of the silica present and the freedom of the feldspar from impurites that will float to the surface and cause spots. Methods of preparation of feldspar are described, and specifications for it are given. M.J.H.

Formula and structural form of attapulgite. J. de Lapparent. *Compt. Rend.*, **202** [21] 1728–31 (1936).—Attapulgite is a type of clayey phyllite of the formula $(OH)_2 \cdot H_3(Mg_2, Al_{4/3}) \cdot Si_4 \cdot H_4O_{16}$ which takes into account the whole amount of water obtained in the analysis. M.H.

Fundamental facts of base exchange. G. Austerweil. *Jour. Soc. Chem. Ind.*, **53** [25] 185–89 (1934).—The chief reaction of base-exchange phenomena is governed by the extraction laws, the base exchanger having the function of a solid solvent, nonmiscible with the liquid solution of the exchanging base. This reaction is limited and governed by the laws of mass action and the phase rule. There are several minor side reactions, the importance of which increases with variation of the composition of the zeolite and variation of the basicity of the exchanging cations. G.R.S.

Geology of deposits of dense magnesite in Greece and Yugoslavia. G. Heissleitner. *Berg- & Hüttenmännisches Jahrbuch*, **82** [1] 24–41 (1934).—Stratigraphy, tectonics, and types of the Mg deposits in peridotite, slate rocks, and limestones of the various districts are described, and the origin, forces present in Mg formation, and age of the various strata are discussed. Maps illustrating the various zones are added. M.H.

History of antimony. J. R. Crandall. *Enamelist*, **13** [7] 35–37 (1936).—The early uses of antimony as a medicine and as a cosmetic are mentioned. Antimony is produced in China, Mexico, Bolivia, Czechoslovakia, and France. The chief minerals containing antimony are the sulfide, various antimonides and sulfantimonides of the heavy metals, and oxidized compounds of secondary origin. In the combustion process of treating low-grade sulfide ores, the sulfur is burned out as SO_2 and the antimony burns to the volatile Sb_2O_3 which is collected in the solid state on cooling. The trioxide is used as an opacifying agent in enamel and glass manufacture. Although color, purity, and fineness are important properties, the bulk specific gravity is also a factor as it may be so light that it is difficult to work. E.J.V.

Ionic exchange and sorption of gases by chabasite. E. Rabinowitch and W. C. Wood. *Trans. Faraday Soc.*, **32** [6] 947–56 (1936).—Chabasite crystals have a skeleton lattice formed by the ions Si^{4+}, Al^{3+}, and O^{2-}. The hollows are occupied by positive ions, chiefly Ca^{2+}, and by the neutral molecules, H_2O. Calcium can be exchanged for other divalent or monovalent ions, and water for other molecules of appropriate size. Sorption by a number of chabasites in which calcium was exchanged for a series of different ions was studied. Replacements of divalent by monovalent ions actually decrease the sorptive capacity of the crystals. The influence of the larger K^+ ions is more pronounced than that of the smaller Na^+ ions. It was difficult to interpret the other details of the experimental results. Sorption equations are given for two cases: (*a*) that of "gaseous" sorbate with molecules freely moving about in the cavities of the crystal, and (*b*) that of a "solid" sorbate, with molecules fixed to definite crystallographic positions. G.R.S.

Kaolin and clay; difference in structure and plasticity.

A. VASEL. *Keram. Rundschau*, **43** [39] 457–60 (1935).—Plasticity in both cases is due to clay substance with the formula $2Al_2O_3 \cdot 4SiO_2 \cdot 3H_2O$. Formerly, the composition $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$ was generally accepted. If clay substance is heated, dehydration takes place; at 900°C and above, an exothermic reaction is noted. V. fired different clays and kaolins containing quartz or feldspar at 1300°C; grains were treated by caustic soda at boiling temperature. Quartz was completely dissolved; it does not react with clay substance. The portion unattacked by soda was alumina silicate; heating does not decompose clay in separate oxides. The composition of the clay residue is approximately $Al_2O_3 \cdot 2SiO_2$ (metakaolin), and that of the kaolin residue, $3Al_2O_3 \cdot 2SiO_2$ (mullite). V. discusses the weathering of feldspars to kaolin and clay with transient formation of mica. Actually there is a formation of kaolin in nature, but the formation of clay seems to belong to the past. The kaolin molecule is three times larger than the clay; thus kaolin is less plastic. F.E.V.

Kyanite operations of Celo Mines, Incorporated. V. L. MATTSON. *Bull. Amer. Ceram. Soc.*, **15** [9] 313–14 (1936).

Methods for determining the value of difficultly fusible materials: II, Sorption capacity of difficultly fusible clays and kaolins. L. BELLADEN. *Metallurgia Ital.*, **28**, 59–63 (1936); abstracted in *Chem. Zentr.*, **ii**, 848 (1936). M.V.C.

Minyulite, a new phosphate mineral from West Australia. E. S. SIMPSON AND C. R. LEMESURIER. *Jour. Roy. Soc. W. Australia*, **19**, 13–16 (1933).—Chemical and physical descriptions are given of a new orthorhombic phosphate of K and Al, found in the altered outcrops of glauconitic coprolite beds of Cretaceous age near Minyula well, Dandaragan, W. Australia. H.H.S.

Nature of clayey raw materials used in the German cement industry. K. ENDELL, U. HOFMANN, AND E. MAEGDEFRAU. *Zement*, **24** [40] 625–33 (1935).—Röntgenographic examinations have shown the following frequent clay minerals: (*a*) "mica clay" (different from halloysite), (*b*) montmorillonite, and (*c*) kaolinite. Conspicuous differences in the fineness of quartz, very important for the velocity of clinker formation, were also observed. Water elimination during firing is regular for mica clay (200 to 600°C) and continuous for montmorillonite up to 200°. At this temperature, 5% only is retained as crystallization water; it disappears above 500°. Crystals of kaolinite are destroyed at 450°C with sudden emission of water. There is a connection between the chemistry of clays and workability by the wet process. Manufacturers using montmorillonite must use the dry process. The importance of colloidal properties for velocity of filtration and water elimination is emphasized. Illustrated. F.E.V.

Observations relative to the mineralogical and chemical history of the fossils of Cornwall. MARTIN HENRY KLAPROTH. Translated in 1786 by John Gottlieb Groschke. Edited by A. L. Curtis with notes by E. H. Davison. Reprinted in *Sands, Clays & Minerals*, **2** [2] 7–25; [3] 26–44 (1935); [4] 23–29 (1936).—The geological formations of Cornwall are discussed; fossils preserved and ore and mineral deposits are described. Methods used at that time to extract W, S, Cu, Zn, Sn, and Co from the minerals are given, with formulas for white and colored glasses, especially Co colors. M.H.

Plasticity of ceramic bodies: III, Swelling of various clays (I). R. ISOMATSU. *Repts. Imp. Ceram. Expt. Inst., Kyoto*, No. 15, pp. 1–16 (1936). **IV, Hydrogen ion concentration of various clays.** *Ibid.*, pp. 17–34. **V, Relation between grinding and plasticity (I).** *Ibid.*, pp. 35–45. M.C.S.

Pyrophyllite, a new development: the Gerhardt deposit. B. C. BURGESS. *Bull. Amer. Ceram. Soc.*, **15** [9] 299–302 (1936).

Quartz crystals. ANON. *Can. Mining Jour.*, **57** [8] 381 (1936).—Deposits of large, perfect quartz crystals, suitable for all purposes, are reported by the Geological Survey of Uganda. G.M.H.

Reticular structure of silica observed in pre-Cambrian rock flints (phtannites) and suessonian phosphates. L. CAYEUX. *Compt. Rend.*, **203** [1] 6–8 (1936).—Two new modifications of the many types of silica found in sedimentary formations are described. They occur in Tunisia. M.H.

Rôle of aluminum in the reactions of clays. H. PAVER AND C. E. MARSHALL. *Chem. & Ind.*, **53** [36] 750–60 (1934).—Whereas lanthanum chloride, ferric chloride, and hexamine cobaltic chloride react with unsaturated clays of the montmorillonite and beidellite types so that the respective cations enter by a normal exchange reaction, aluminum chloride solutions do not react with hydrogen clays in this way. The absorption of aluminum found at low concentrations of the chloride or sulfate is due to precipitation of aluminum hydroxide. The liberation of aluminum from unsaturated clays and neutral salt solutions is due to direct exchange, not to solution of the aluminum from the clay by acid liberated by base exchange. The aluminum set free is only approximately equivalent to the total acidity at high concentrations of the neutral salt used. In all cases hydrogen is exchanged along with aluminum. The reduction in base-exchange capacity observed when clays are treated with aluminum salts is caused by a precipitation of aluminum hydroxide within the clay micellae. Two new hypotheses are proposed in explanation of the results. Both postulate that unsaturated clays are to be regarded as mixed aluminum-hydrogen clays rather than pure hydrogen clays. G.R.S.

State in which the hygroscopic moisture exists in soils as indicated by its determination with alcohol. G. J. BOUYOUCOS. *Soil Sci.*, **41** [6] 443–47 (1936).—Hitherto it has not been definitely known whether the hygroscopic moisture of soils, which is driven off by heating at 110°C, exists exclusively as film or physically adsorbed water or partly as chemically combined water. An attempt was made to throw light upon this question by extracting soils with alcohol and then determining the quantity of water found in the alcoholic extract. By means of a special reagent consisting of fusel oil, toluene, and tartaric acid, the water extracted by the alcohol can be determined volumetrically. In the case of mineral soils, the alcohol extracts all the hygroscopic water, indicating that the hygroscopic moisture in mineral soils exists entirely in the form of physically adsorbed or film water. In the case of mucks and peats and other organic materials studied, the alcohol extracts about one third less water than is indi-

cated by the oven-dry method. The explanation for this is either that the alcohol is unable to extract all the water from the organic materials or that the oven-dry method causes these organic materials to undergo partial decomposition or volatilization of substances other than water, with consequent high and erroneous values for hygroscopic water. The latter possibility seems more likely. G.R.S.

Titanium and its more useful compounds. R. M. McKinney and W. H. Madson. *Jour. Chem. Ed.*, **13** [4] 155–59 (1936).—The history, occurrence, chemistry, and tests for titanium and its compounds are discussed. Titanium dioxide has been used for a long time for the production of a honey-yellow underglaze on pottery and in the production of an ivory-white enamel for making artificial teeth. Titanium compounds have been used for coloring many clay products and are becoming increasingly important in the manufacture of refractory and acid-resisting materials. M.J.H.

BOOKS AND BULLETINS

Canadian Mineral Industry, 1935. *Can. Dept. Mines, Mines Branch, Pub.* No. 773 (1936). 100 pp. Price 25¢. The mineral situation in Canada is outlined under fifty headings from the standpoint of actual and prospective producing localities, production, and trade. G.M.H.

Scientific Study of Soviet Mineral Resources. A. E. Fersman. Edited by C. P. Dutt. 149 pp. + 15 plates. International Publishers, New York. Briefly reviewed in *Nature*, **138** [3481] 97–98 (1936).—A brief outline of the achievements of mineralogists and geochemists in Soviet Russia during the last five or six years is given. J.L.G.

Shifts in sources of chromite supply. R. H. Ridgway. *Bur. Mines Information Circ.*, No. 6886, 11 pp. Free. Economic factors affecting the chromite industry in all countries that are sources of chromite are discussed. It includes two "pie" charts and maps of the world with the percentage of world supply shown by countries. R.A.H.

Soils, Their Origin, Constitution, and Classification; An Introduction to Pedology. G. W. Robinson. 2d ed. Thomas Murby and Co., London, 1936. xvii + 442 pp., 5 plates. Price 20s net. Briefly reviewed in *Nature*, **138** [3479] 9 (1936).—The new edition has added to the bibliography and contains discussions on recent work on the clay complex, base exchange, and soil moisture. Geographical and genetic aspects of soils are stressed. J.L.G.

Textbook of Mineralogy (Lehrbuch der Mineralogie). Klockmann. 11th ed. Revised and edited by Paul Ramdohr. F. Enke, Stuttgart. xii + 625 pp., 613 figs. Price (paper) 34 Rm. Briefly reviewed in *Econ. Geol.*, **31** [4] 436 (1936).—The reviewer regards this work as probably the most modern text on minerals and their properties now in print. In addition to the usual considerations, the physical chemistry of crystals is discussed, and the use of X-rays in the investigation of mineral structure is clearly outlined for the reader who is not familiar with this development. J.L.G.

Chemistry and Physics

Birefringence measurements in the far ultra-violet. R. Servant. *Compt. Rend.*, **202** [21] 1771–73 (1936).—Numerical results of measurements of barite and gypsum are given for the range 2520 to 1968Å; the method is described. M.H.

Constitution of silicate glasses on the basis of the Biltz-Weibke hypothesis. O. Knapp. *Keram. Rundschau*, **43** [36] 423–24 (1935).—According to Kopp's law, molecular volumes of liquids may be approximately calculated by the addition of volumes of the constituents. Biltz and Weibke have verified the validity of this rule for solid bodies if the constituents remain in the same physical state. Crystallized silicates possess volume additivity if separate oxides are considered as constituents. According to Biltz's hypothesis, technical glasses are composed of mono- and di-metasilicates and in some cases of mono-orthosilicates with some excess of silica. Agreement between calculated and determined values is satisfactory for soda-soluble, barium, lime, and magnesia glasses. Zinc, lead, boron, and alumina glasses have important discrepancies. This new hypothesis can not be a basis for a general glass theory because the diagrams of stable silicate compounds are not completely known. In the new hypothesis, the existence of devitrite and of $4K_2O \cdot CaO \cdot 10SiO_2$ is not understandable. K. has measured the refractive index of different glasses and found disagreement with results of calculations. F.E.V.

Contemporary advances in physics: XXVII, The nucleus, second part. K. K. Darrow. *Bell System Tech. Jour.*, **13** [1] 102–58 (1934).—Transmutation is the major subject, *i.e.*, the alteration or disintegration of a nucleus, the unique and distinctive part of any atom, by impacts of fast-moving corpuscles. Transmutation of some elements is practicable with protons of a relatively modest energy which can be produced in laboratories without any serious difficulty. It is due partly to the discovery of neutrons and deutons, particles which apparently possess remarkable ability in effecting certain kinds of transmutation. It is also due to advances and refinements in the methods of working with alpha particles, the first variety of corpuscle with which disintegration of nuclei was ever achieved. "Nuclear chemistry" is being recognized as a special branch of science, and this is almost justified by the number of cases known in which two nuclei interact and produce two others which are recognizable. **XXVIII, The nucleus, third part.** *Ibid.*, [3] 391–404.—Remarkable cases discovered include a great number in which the impact of one nucleus upon another (or of a neutron on a nucleus) provokes an instantaneous transmutation which is followed after seconds, minutes, or hours by the spontaneous breaking-apart of one of the resultant nuclei. It may be said that these last are the nuclei of new kinds of radioactive elements, and the phenomena are often called "induced radioactivity," but many of these new unstable elements differ from all radioactive bodies hitherto known in that they emit positive electrons. Some additional examples of transmutation are described. *Ibid.*, [4] 580–613.—D. deals first with the newer knowledge of alpha-particle emission: that form of radioactivity in which massive atom-nuclei disintegrate of themselves

emitting helium nuclei (alpha-particles) and also corpuscles of energy in the form of gamma rays or high-frequency light. He describes the contemporary picture of the atom-nucleus, in which this appears as a very small region of space containing various charged particles, surrounded by a potential barrier; the charged particles within or those approaching from without are, by the doctrine of quantum mechanics, sometimes capable of traversing the barrier even when they do not have sufficient energy to surmount it. The exponential law of radioactivity, *viz.*, that the choice between disintegration and survival for any nucleus at any moment seems to be altogether a matter of pure chance, then appears not as a singularity of nuclei, but as a manifestation of the general principle of quantum mechanics (the principle that the underlying laws of nature are laws of probability). Moreover, it is evident that transmutation of nuclei by impinging charged particles, instead of beginning suddenly at a high critical value of the energy of these particles, should increase gradually and smoothly with increasing energy, and might be observed with energy-values so low as to be incomprehensible otherwise; this agrees with experience. **XXIX, The nucleus, fourth part.** *Ibid.*, **14** [2] 285–321 (1935).—Two properties of nuclei, *viz.*, magnetic moment and angular momentum, are discussed. Since these exhibit themselves chiefly by influencing the spectra of the atoms to which the nuclei belong, most of the article is concerned with various laws of atomic spectra; advantage is taken of the opportunity to describe some features of the electron system surrounding the nuclei and to explain how the concept of the spinning electron enters into atomic physics. An account follows of various experiments in which streams of atoms are deflected by inhomogeneous magnetic fields, and the laws of the deflections indicate the magnetic moment or the angular momentum of the nucleus or both. Finally there is a summary and tabulation of existing knowledge of these quantities. H.E.S.

Determination of tin in presence of antimony and lead. H. F. Hourigan. *Analyst*, **61**, 328–33 (1936).—The iodate titration of $SnCl_2$ is examined for interfering elements. H.H.S.

Friction and adhesion: V, Theory of adhesion. B. Deryagin. *Zhur. Fiz. Khim.*, **6**, 1306–19 (1936); for Part IV see *Ceram. Abs.*, **15** [7] 220 (1936). P.B. & E.S.

Hydrolitic equilibriums of calcium aluminate hydrates. E. von Polheim. *Zement*, **24** [41] 643–48; [42] 659–63; [43] 677–83 (1935).—Equilibriums between these hydrates and their solutions are important because different hydrates are possible. Each needs a different lime concentration in the liquid phase. The knowledge of this concentration is necessary to understand the behavior of cement in the presence of aggressive gases or liquids. At temperatures between 20 and 40°C it is difficult to reach genuine equilibriums because reactions are slow and the tendency to crystallization is variable. Unstable intermediary products are met with. Results of tests may be summarized as follows: (1) At 20°C, three hydrates may be in equilibrium with each other and with their solutions according to the lime and alumina contents of the liquid phase. (2) In each case a precipitate containing two solid phases is in equilibrium with the liquid phase; the precipitates are constituted by aluminum hydroxide and dicalcium aluminate hydrate, dicalcium and tricalcium aluminate hydrate, or tricalcium and tetracalcium aluminate hydrate. Concentrations of lime and alumina in the liquid phase were determined for the limits of stability. (3) The three hydrates crystallize in small slabs as formerly described. (4) Finely divided dicalcium aluminate hydrate gives to the liquid a silky appearance which is a sure testimonial of the presence of this hydrate. (5) At 37°C, all hydrates are transformed in tricalcium aluminate hydrates. F.E.V.

Interesting infra-red absorption band in fused quartz. J. W. Ellis and W. K. Lyon. *Nature*, **137** [3477] 1031–32 (1936).—The authors believe that the absorption of infra-red radiation at a wave-length of 2.7 μ by certain samples of fused quartz is due to the presence of traces of water or CO_2. These substances have absorption bands in or near that region. J.L.G.

Microchemistry; a new engineering aid. Charles Van Brunt. *Gen. Elec. Rev.*, **39** [2] 88–94 (1936).—Microchemistry is essentially the art of dealing chemically with minute quantities of matter. Tiny size no longer prohibits chemical analysis, as the range of workable samples extends downward to one-millionth of conventional size. The chemist can now aid the engineer in problems concerning mere specks. A general discussion of microanalytical methods, such as fractional distillation, sublimation, microfusion, electrolysis, etc., is given. L.E.T.

Presence of manganese in natural carbonates and silicates important to the silicate industry and the determination of manganese with special consideration to Knorr's method. O. Kallauner and L. Matoušek. *Stavivo*, p. 385 (1935).—This is a modification of Knorr's titrate method. The acidity of the solution does not increase above 10% of H_2SO_4 because then all manganese frees itself as an insoluble superoxide. Filtration by means of two paper filters leads to lower results owing to the less perfect separation and accumulation of superoxide. The ammonium sulfate, even in a relatively strong concentration, has no effect on the results. In the presence of small quantities of manganese it is necessary to heat the solution for a long time to get a satisfactory separation of the superoxide, and therefore the calorimetric method is a more suitable one. Knorr's method is modified through filtration in Gook's crucibles; the superoxide dissolves in the $n/10$ $C_2H_2O_4$ and its surplus titres $n/10$ MnO_4. R.B.

Reactions of cerium and other salts with methylene blue. L. Passerini and Michelotti. *Gazz. Chim. Ital.*, **65** [8] 824–32 (1935).—The reactions of salts of Ce, Hg, Ir, Pd, Au, Pt, Mo, and K with methylene blue, the characteristic colorations, and the products formed are compiled in a table. Ce salts are particularly easily recognized, even in the presence of other elements, by their intense scarlet-red coloration. M.H.

Separation in stages and efficiency. J. P. Treub. *Chem. Weekblad*, **33** [33] 496–500 (1936).—A method is shown for constructing a diagram of separation of a mixture into its constituents, which can be employed in cases where chemical analysis offers difficulties. An example demonstrates the most economical way to effect separation with the aid of this diagram. M.H.

Softening of vitrified materials. EDUARD RENCKER. *Ann. Chim.*, **4**, 523–66 (1935); abstracted in *Chem. Zentr.*, ii, 421 (1936).—The relationship between the transformation point and incipient softening of vitrified materials was studied. See *Ceram. Abs.*, **13** [10] 255 (1934). M.V.C.

Studies on aluminium oxide by means of electronic rays. E. BELWE. *Z. Physik*, **100** [3] 192–96 (1936).—When alumina is exposed to electronic rays, interference lines are obtained which allow conclusions to be drawn regarding its structure. Two types of alumina were examined: (1) alumina made by an electrolytic oxidation, and (2) alumina made by the oxidation of metal foil in a flame. Electrolytic alumina consists of a very finely crystalline γ-alumina. Alumina made in the flame consists of the usual coarsely crystalline form with crystals of metallic aluminium interspersed in it. L.T.B.

System K_2O–PbO–SiO_2. R. F. GELLER AND E. N. BUNTING. *Jour. Research Nat. Bur. Stand.*, **17** [2] 277–89 (1936); R.P. 911. Price 5¢.—The system was investigated by means of well-known methods involving quenching, petrographic examination, and heating curves. Five ternary compounds were identified optically in the system K_2O·SiO_2–PbO–SiO_2, and the compositions of four of these were established. The first, crystallizing as hexagonal plates with a melting point at 918°C, is uniaxial negative, and the optic axis is perpendicular to the cleavage. The second, crystallizing as well-defined fibers or laths, melting at 779°C, and resembling a short-fibered asbestos when crushed, has the optic axis parallel with the longitudinal axis. The third is positive biaxial and crystallizes as rectangular, platy granules of parallel extinction which melt at 757°C. The fourth is platy, melts incongruently at 735°C, and is very unstable. The crystalline phase of undetermined composition apparently melts incongruently at about 750°C to form glass and SiO_2. Unfortunately, all the glasses examined (which otherwise held promise of usefulness as glazes) on heating and cooling undergo volume changes so great as to preclude their use on clayware as now manufactured, with the exception of certain "high silica" and "high talc" wall tile. R.A.H.

Thermal decomposition of kaolin and the compositions issuing from it under higher temperatures. O. F. HONUS. *Stavivo*, p. 387 (1935). R.B.

BOOKS

Hydrofluoric and Fluosilicic Acids and Their Metallic Salts: Vol. 24 (Flussaüre, Kieselflusssaüre und deren Metallsaltze). OSKAR KAUSCH. Enke's Library of Chemistry and Technique. Edited by Ludwig Vanino. 438 pp. Reviewed in *Glashütte*, **66** [20] 349 (1936); *Sprechsaal*, **69** [24] 352 (1936).—The following topics are discussed: (1) hydrofluoric acid, its properties, formation, and preparation; (2) fluosilicic acid, its properties and production, and metallic silicofluorides; (3) metallic fluorides and double fluorides; (4) analysis of hydrofluoric and fluosilicic acid and their metallic salts; (5) uses of hydrofluoric and fluosilicic acids and their metallic salts. The last part deals with the use of these materials in the glass industry. Numerous patents are mentioned. M.V.C.

Microgas Analysis and Its Application (Die Mikrogasanalyse und ihre Anwendung). HEINRICH SCHWARZ. Emil Haim and Co., Vienna and Leipzig, 1935. 286 pp. Price (paper) 21 Rm.; (linen) 22.80 Rm. Reviewed in *Ind. Eng. Chem., News Ed.*, **13** [6] 116–17 (1935). F.G.H.

Theory of Emulsions and Their Technical Treatment. WILLIAM CLAYTON. J. and A. Churchill, London, 1935. 459 pp. Price 25s. Reviewed in *Trans. Faraday Soc.*, **32** [6] 972 (1936).—The very large technical literature on emulsions has been incorporated. There is an equally thorough treatment on colloid mills, homogenizers, and the manifold devices used for de-emulsification, inversion of emulsions, and multiple emulsions. G.R.S.

PATENTS

Alkaline trisodium phosphate. HOWARD ADLER (Victor Chemical Works). U. S. 2,050,249, Aug. 11, 1936 (April 9, 1934).

Method of producing persilicates of increased stability with high content of hydrogen peroxide or active oxygen. F. KRAUSS. Brit. 452,144, Sept. 2, 1936 (Dec. 15, 1933).

Process for making sodium aluminate. O. A. OLSEN. U. S. 2,052,486, Aug. 25, 1936 (Feb. 5, 1934). A process for making sodium aluminate comprises adding sodium hydroxide to an aqueous solution of aluminum sulfate, adding substantially anhydrous alcohol, removing sodium sulfate from the alcoholic solution of sodium aluminate, and separating the sodium aluminate by distillation.

Process of treating zinc oxide. HUGO REINHARD (Wilhelm Grillo Handelsges. m.b.H.). U. S. 2,053,249, Sept. 1, 1936 (June 20, 1934). The method of producing zinc oxide comprises vaporizing zinc metal by boiling in an externally heated muffle, burning the vapors within a combustion chamber in the presence of a quantity of oxygen-containing gas sufficient to oxidize the vapors and to convey the oxidized product to a precipitation zone, and simultaneously retarding the flow and the rate of cooling of the resultant fumes within the range from 800 to 500°C.

Treatment of clays, etc. WILLIAM FELDENHEIMER. U. S. 2,053,329, Sept. 8, 1936 (Aug. 23, 1935). In the treatment of clays, etc., to improve their color, the step comprises treating the clay in the wet state with a soluble chromous salt.

General

Filtration of air in foundries. O. TH. KORITNIG. *Giesserei*, **23** [12] 295–98 (1936).—The hygienic and economic harmfulness of the dusts in foundries is pointed out, and means for removal by filtering or electrical precipitation and the respective advantages of these methods are discussed. M.H.

Health hazards in industry. F. N. FEATONBY. *Jour. Australian Chem. Inst.*, **3** [7] 199 (1936).—Most important of industrial hazards is inhalation of very fine dusts, especially siliceous dusts, although Pb attacks most dangerously on the respiratory tract. Accident proneness (25% of workers being in 75% of accidents) is noted. A bibliography of the Australian Commonwealth Dept. of Health service publications on the subject is attached. H.H.S.

Influence of constant items in the production cost of brickworks. O. KALLAUNER. *Stavivo*, p. 68 (1936).—K. gives a report concerning W. Herrich's formula $Cz = \frac{Mz}{100-Mz} n$, where Cz is the percentage of the increase of the fundamental cost of production, C, Mz is the percentage of the decrease in the amount of the goods produced as against the optimum amount, M, and n is the percentage by which the constant items in the cost of production burden the fundamental cost of production. R.B.

Joosten process of chemical consolidation of loose soils. EDITORIAL. *Indian Concrete Jour.*, **9** [11] 382 (1935).—The Joosten process of consolidating loose soils, invented by H. Joosten in Germany, is described both in its chemical and mechanical aspect. It enables loose sand or gravel in a tunnel or shaft to be transformed into a coherent layer impervious to water. It requires great skill and experience and is rather expensive owing to the large consumption of chemicals. A.P.S.

Lalor Foundation: fellowships available. ANON. *Bull. Amer. Ceram. Soc.*, **15** [9] 321 (1936).

Report of the activity of the State Experimental Institute for the Silicate Industry in Brno, 1935. O. KALLAUNER. *Stavivo*, p. 23 (1936).—The staff includes four permanent university professors, three university assistants, five other trained workers, and one outside expert. Forty-six papers have been published. R.B.

Russian ceramics in the vicinity of Tiflis. JOSEF ŠIMÁK. *Stavivo*, p. 13 (1936).—A ceramic school at Mcchat, about 20 kilometers from Tiflis in Caucasus, was founded in 1912 by a Czechoslovak, Nikolaj Feodorovič Rudolf. Before the World War this school had become well known through the products of the academic painter, Vasilij Šebujev. Illustrated. R.B.

Salts of silicomolybdic acid with organic bases; gravimetric determination of small amounts of silica as pyramidon-silicomolybdate. E. J. KING AND J. L. WATSON. *Mikrochemie*, **20** [1] 49–56 (1936).—In dilute acid solution, one part of silica (SiO_2) combines with 12 parts of molybdate (MoO_3) to form a stable complex called silicomolybdic acid. This acid forms insoluble compounds with organic bases, such as coniine, pyridine, pyramidon, and others. The silica content of tissues, such as human lung, silicotic lung, etc., have been tested by different methods, *viz.*, the pyramidon silicomolybdate method, gravimetric method (HF), and colorimetric method. See "Gravimetric—" *Ceram. Abs.*, **15** [3] 107 (1936). L.E.T.

Survey of engineering and metallurgical progress. G. E. WOLSTENHOLME. *Proc. Inst. Mech. Engrs.*, **131**, 625–29 (1935).—Change and development of engineering methods in the last forty years are reviewed. M.H.

Visit to Raniganj. ANON. *Trans. Mining & Geol. Inst. India*, **30** [2] 117–24 (1936).—The manufacture of salt-glazed pipes, refractory fireclay materials, white glazed pottery ware, silica brick, and magnesite and chrome brick in the pottery works (originally founded in 1860 and the largest in India today) of Burn & Co., Ltd., Raniganj, is described. A.P.S.

Working methods of a modern research laboratory in developing aluminum alloys. A. V. ZEERLEDER. *Aluminium*, **18** [7] 297–98 (1936).—Experiments and the manner of procedure in testing properties of new materials and releasing them for commercial exploitation after they have been found satisfactory are described. M.H.

BOOKS

Chemical Engineer. General Index for Vols. I and II (Der Chemie Ingenieur). A. EUCKEN AND M. JAKOB. Akademische Verlagsges. m.b.H., Leipzig, 1935. 99 pp. Price (bound) 8.80 Rm; (unbound) 7.70 Rm. Reviewed in *Ind. Eng. Chem., News Ed.*, **13** [15] 325 (1935).—This very complete and detailed subject index of the material in the two volumes of the handbook includes operations, illustrations, equipment, materials, and calculations. F.G.H.

German-English Chemical Terminology. ALEXANDER KING AND HANS FROMHERZ. D. Van Nostrand Co., Inc., New York, 1935. 324 pp. Price $5.00. Reviewed in *Ind. Eng. Chem., News Ed.*, **13** [9] 209 (1935). F.G.H.

Libraries for Scientific Research in Europe and America. H. PHILIP SPRATT. Grafton and Co., London, 1936. 227 pp. Price 10s 6d net. Briefly reviewed in *Nature*, **138** [3480] 59 (1936).—Libraries in London, Paris, Brussels, Scandinavia, Germany, Poland, and Russia are described in detail in the first part. The second half is devoted to American libraries. Types of catalogs, indexes, and classifications are given for each library. Information services and photostat and photograph services are listed. About 100 libraries are considered. J.L.G.

Progress at Mellon Institute during 1934-35. E. R. WEIDLEIN. Twenty-Second Annual Rept. of Director to Trustees of Mellon Inst.; abstracted in *Ind. Eng. Chem., News Ed.*, **13** [8] 162–66 (1935).—Advances in enamel procedure and new methods for testing refractories are included. F.G.H.

Publications of the Kaiser Wilhelm-Institute for Silicate Research in Berlin-Dahlem (Veröffentlichungen aus dem Kaiser Wilhelm-Institut für Silikatforschung in Berlin-Dahlem). ANON. Friedr. Vieweg & Sohn, Brunswick, 1935. 203 pp. Price 12.50 Rm. Articles on the following subjects are included: (1) Cement: how magnesia is combined in Portland cements; the influence of the magnesia content of clinker on the ferrite of tetra-aluminate of calcium; (2) Pure science: researches on the stability of aluminates; relation between the composition of calcined clinkers and the exothermic effect during setting; and (3) Glass: physical and chemical properties of beryllium glasses; examination and identification of the surface of glasses after their radiochemical activity; study of currents and their effects on the production of entirely automatic machines for bottles; processes of manufacture, coloration of glasses, röntgenograms, chemical analyses of certain compounds, and optical examination of absorption spectra in connection with the constitution of solutions and glasses. M.V.C.

"Sprechsaal" Yearbook for 1936, for Ceramics, Glass, and Enamel (Sprechsaalkalender 1936 für Keramik, Glas, Email). J. KOERNER. Müller and Schmidt, Coburg, 1936. Reviewed in *Brit. Clayworker*, **45** [532] 161 (1936). A combined diary and up-to-date technical reference book. R.A.H.

OFFICIAL PERSONNEL OF DIVISIONS, 1936 to 1937

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Rules	L. E. Barringer	R. D. Landrum	H. R. Lillie	W. J. Watkins	K. E. Buck	C. F. Tefft		J. R. Beam
Councillors			U. E. Bowes G. W. Morey	C. H. Peddrick, Jr. V. V. Kelsey				T. A. Klinefelter
Management				R. R. Robinson				
Statistics				K. E. Ward				